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The Journal of Bone and Joint Surgery

The Journal of
Bone and Joint Surgery

EDITORIALS

PROTRUDED DISCS AND PAINFUL BACKS

The suggestion that a small bit of normal or near normal disc tissue could, by impingement on a nerve root in the spinal canal, cause low back and sciatic pain was made by Goldthwait forty years ago. The first report of a series of cases treated by surgical excision of protruded disc tissue was made twenty-three years later. Since 1934 the literature on the subject has become voluminous. The reader, in his attempt to separate fact from fancy, may easily become baffled and bewildered. Two excellent articles in this number of the Journal will repay the reader's careful scrutiny. O'Connell has reviewed the findings and results in 500 surgically treated patients with disc lesions. That the most common provable cause of sciatica is root pressure from a protruded disc is well established. The clinical picture is well delineated and is recognised as an established syndrome.

The etiology of disc protrusions is still *sub judice*. Among the factors to be considered are acute trauma, the repetitious trauma of heavy labour and of routine daily activities, congenital disc defects or weaknesses, pregnancy and labour in the female patient, and degenerative disc lesions. The analogy of disc protrusions to an automobile tyre failure seems apt. The tyre, when it leaves the factory, may have a defect in the fabric (congenital weakness) so that it blows out while rolling along a smooth road. A tyre may blow out when it strikes a stone or curb (acute trauma), or it may give way thousands of miles later. A tyre exposed to gasoline (petrol to our English friends) ages rapidly, and degenerative change produces early tyre failure.

The clinical findings of patients with sciatica due to disc lesions have been carefully studied by many observers. The clinical diagnosis and localisation of the lesion is becoming increasingly accurate and O'Connell, in company with a number of other neurosurgeons on both sides of the Atlantic, rarely uses myelography. But modern myelographic technique, in which the contrast medium, pantopaque, is removed immediately upon conclusion of the examination, is safe and not particularly difficult. It often yields most important information not obtainable by clinical examination. Toumey *et al.** have shown that certain cauda equina tumours are clinically indistinguishable from disc lesions. In their series, tumours represented 4·3 per cent of all surgically treated low back lesions. " The myelogram is the most significant and valuable aid in differential diagnosis." Those who do disc surgery without myelography must accept a small but definite risk of missing a tumour.

The technique of surgical removal of an offending disc has been greatly refined. The mortality in skilled hands is less than 1 per cent, and surgical complications are neither frequent nor, as a rule, serious. O'Connell's results testify to the fact that about 90 per cent of properly selected and treated cases will be either cured or greatly improved. But there is a failure rate of 10 per cent in skilled hands (higher in the less proficient) and there is a second larger group of patients, approximately 40 per cent, who, on careful questioning, admit to some degree of disability. With admirable candour Armstrong has recognised that occasionally

* Toumey, J. W., Poppin, J. L., and Hurley, M. T. (1950): Cauda equina tumours as a cause of the low back syndrome. Journal of Bone and Joint Surgery, **32-A**, 249.

we should cease giving ourselves congratulatory accolades for work well done and face up to our failures. He has listed and discussed the causes of failure in such a straightforward fashion that his conclusions will be generally accepted. Certain difficulties are obvious. The surgeon must first make proper selection of his operative cases. In the surgical amphitheatre he must steer a course between the Scylla of inadequate exposure of the lesion and the Charybdis of damaging or weakening important structures. The operation may be deceptively easy or may tax one's operative skill to the utmost. Many surgeons of experience will question Armstrong's statement that 15 to 20 per cent of all patients have double lesions. The second lesion which he finds so frequently may, in many instances, be the *knorpelknötchen*, described by Andrae and Schmorl, which are anatomical variations of no clinical significance.

On the problem of the combined operation of disc removal and arthrodesis, adequate statistical evidence is not yet available. The fact is that in many of the large centres in the United States, including the Mayo Clinic and the Massachusetts General Hospital, the combined operation is advised in many instances, and a considerable proportion of the disc cases undergo immediate arthrodesis. There is considerable evidence that an unstable spine is one of the most common causes of unsatisfactory results.

The recognition of a new syndrome raises as many new problems as it solves but this Johnny-come-lately among recognised diagnostic entities has survived almost two decades since its forcible extraction from the womb of the unknown. It appears to be maturing satisfactorily in spite of adolescent megrims.

JOSEPH S. BARR.

PROTRUSION OF LUMBAR INTERVERTEBRAL DISC

The discovery of Mixter and Barr that sciatica could be caused by a disc protrusion started a movement which led to a great clarification of thought on peripheral pain in general. It came to be realised that practically all sciatica and recurrent lumbago is due to a disc lesion and that chronic back pain is often due to its effects. The same view is held of pain in the neck and down the arm. The old conception of fibrositis, idiopathic neuritis and rheumatism, due to wet and cold and toxins in the blood, has been swept away. Rheumatism has come to imply rheumatoid or osteoarthritis and the hobby horse, fibrositis, is forgot.

Little has been published on the subject by surgeons, at least in this country, during the last three or four years. However, that work was going on and that the ground is now more fully consolidated and mapped out is shown by O'Connell's and Armstrong's papers in this number, and by Young's* recent article in the *Lancet*. The Journal is fortunate in being able to publish O'Connell's Hunterian lecture. As is to be expected from a distinguished neurological surgeon, it gives not only a complete and detailed record of personal observations on the clinical and operative findings in sciatica, but also a sound interpretation of them. His results are unsurpassed, although there are, of course, a proportion which cannot be classed higher than "improved." Armstrong in his paper pursues a particularly useful inquiry into the causes of failure.

The diagnosis is nearly always easy. It depends largely on the history and on a plain radiograph, which will either be normal or show a diminished joint space. Also important are the back signs, straight leg raising and neurological signs. O'Connell regards myelography and routine lumbar puncture as unnecessary and with this most surgeons would certainly agree. It is possible that the importance of neurological signs is stressed unduly. An examination for them is certainly essential to exclude a nerve lesion causing wider effects, but one very often has to make the diagnosis, and not infrequently to operate, in their absence. Nor are neurological signs accurate in localisation, particularly in the lower two spaces. As O'Connell's tables show, they can at most suggest a probability, and he has

* BURNS, B. H., and YOUNG, R. H. (1951): Results of Surgery in Sciatica and Low Back Pain. Lancet, **i**, 245.

presented an additional and original explanation for this in what he calls occult sacralisation. Here the lowest free vertebra is on a higher level than usual and the upper component of the sciatic nerve comes out below instead of above it. O'Connell makes the important observation that a reliable estimate of the amount of pain is given by the degree of restriction of straight leg raising—presumably in sciatica only; it naturally does not apply in acute lumbago from a disc lesion. It may also be added that the greater the restriction of straight leg raising, the larger the protrusion.

Armstrong and O'Connell are agreed on the position for operation. Both have the patient lying on his side. They hold different views on the extent of the exposure. O'Connell favours a limited, interlaminar approach. Armstrong removes the fifth spine and most of the lamina, obtaining thereby a comprehensive view, and he sets out his reasons, with which the writer concurs, for doing so. However, with O'Connell's results the alternative cannot be claimed to be *more* successful, but it may, at least, be said for the wider approach that it has an advantage when searching for a less definite lesion, and perhaps for the safe removal of a difficult one. There is no evidence that it weakens the back. The two papers express opposite views on post-operative treatment. The fact that O'Connell uses early exercises and Armstrong advocates rest " to let the irritated joint settle down " suggests that—as both get good results—its importance can be exaggerated. Perhaps the truth is that here, as in many other surgical procedures, when the primary treatment is satisfactory, after-treatment is usually adequately performed by Nature, guided by an occasional word of advice and encouragement.

O'Connell's results must be attributed largely to operative skill and experience, but also in part to the selection of cases. The higher the threshold to operation the better will be the results. Where a wider range is included they will not be so good. The best results are to be obtained in patients with large protrusions, as in full-blown sciatica, for the protrusion is then easy both to define and to eradicate. If the operation is done in a quiescent interval, no matter how severe and frequent the attacks have been, the protrusion may be missed. Although it is not widely accepted, the inference seems to be inescapable that protrusions do reduce spontaneously. It is difficult to account for repeated attacks on any other hypothesis. In a few cases that were explored for chronic backache neither O'Connell nor Armstrong found a definite protrusion but, in the writer's experience, evidence of a degenerated disc may often be found. This sort of case is now treated by grafting, but unfortunately it is not always possible to ensure sound fusion of the last two lumbar vertebrae and the sacrum.

In discussing the causes of failure Armstrong finds that one of the commonest causes, when a lesion has been found, is a recurrence of protrusion from the same disc, due to insufficient material having been removed. This is particularly likely to happen in partial lesions—Young's " unripe " disc. Here only part of the nucleus is sequestrated and the remainder is apt to be left behind with the danger of subsequent extrusion.

The fear of causing paralysis has been grossly exaggerated, and indeed it seems doubtful whether O'Connell's two deaths could be attributed to the operation. The widespread reluctance to recommend operation, even in the more severe cases, was born of the many failures, and even occasional disasters, inevitable in the exploration and development of a new field of surgery. O'Connell remarks that in his first twenty-six operations he failed to find a protrusion nearly so often as he did subsequently. He now draws blank in only one in forty. The experience of other surgeons has been similar. However, there is now no necessity to acquire experience the hard way, for anyone who wishes can receive the necessary training. It should therefore be possible for operation to assume more generally its rightful place in treatment. As these papers show, in experienced hands a patient is extremely unlikely to be made worse. This is of prime importance and it emphasizes that one should set a term to conservatism. It certainly need not be carried to the limit of the patient's tolerance.

B. H. BURNS.

ACUTE HAEMATOGENOUS OSTEOMYELITIS

Acute haematogenous osteomyelitis need not, and should not, be a fatal or crippling disease. Early and adequate treatment with penicillin and sulphadiazine aborts the disease with minimal bone change and lowers the mortality almost to zero.

Following the teaching of the late Professor C. L. Starr many early operations were done in the past in Toronto. But early operation may have no place in the treatment of acute osteomyelitis. Patients do not die because one neglects to drain an abscess in bone. They die because of an overwhelming septicaemia as shown at autopsy. There is some evidence that the extent of bone necrosis has been determined by the time the patient reaches hospital and that incision and drainage, with or without multiple drill holes in the bone, do not influence the amount of bone destruction. But that is controversial. Certainly reports in the literature are conflicting. Probably the truth lies somewhere between the firmly held convictions of the proponents of incision and drainage and of those who believe in conservative treatment. John B. Murphy said that where there is pus it should be let out, but he did not know Florey and Fleming. Probably the question could be settled with certainty only by a large series in which alternate patients were operated on. Experience is still fallacious and judgment difficult even after the advent of antibiotics. Infants and children do well on penicillin therapy without operation. Perhaps they would do better with penicillin and incision and drainage.

But the main point at issue really is that an early diagnosis be made and adequate treatment started at once. If this is done within twenty-four hours of onset, osteomyelitis is simply not a problem. It makes very little difference if a patient with rheumatic fever is given penicillin for a day or two; it makes a very great difference indeed, both to life and to limb, if a patient with osteomyelitis is given salicylates instead of penicillin. And surgeons must continue to teach medical students and general practitioners the vital importance of early diagnosis and to re-emphasize the fact that radiographs are useless for that purpose.

Many haemolytic staphylococci are penicillin-resistant. It takes at least forty-eight hours before the penicillin sensitivity of the infecting organism can be determined. Therefore it has been the practice at the Hospital for Sick Children in Toronto to give both penicillin and sulphadiazine until the penicillin-sensitivity is ascertained. Two grains of sulphadiazine (which is not a dangerous drug in children) per pound of body-weight are given in twenty-four hours, and 50,000 to 100,000 units of penicillin intramuscularly every three hours. Aureomycin and terramycin have not been used routinely. Usually treatment is continued for three weeks. There is general agreement on the importance of early and adequate penicillin therapy, the intravenous administration of fluids, electrolytes and blood, and the immobilisation of the affected extremity.

With this method of treatment patients do very well indeed. The temperature falls to normal and the local signs and symptoms subside rapidly. As Altemeier has said, the results seem to vary with the duration of the disease before treatment is begun, with the dosage of penicillin used, and with the severity of the individual infection.

Sequestrectomy, which is not often necessary, should be done when the sequestrum has separated. Small sequestra will become revascularised, like a bone graft; large, loose ones will not. They should be removed and the incision closed by primary suture. In chronic osteomyelitis antibiotics are very useful but they are not a substitute for adequate operation.

Enthusiasm in surgery is best tempered by years of experience. It is impossible not to be enthusiastic about the immediate results in osteomyelitis; about the late results it is too soon to speak. As reported in this number of the Journal, Professor Gallie has recently drained an abscess and removed a sequestrum of the femur in a woman of ninety-one years who had had osteomyelitis at the age of eleven—an eighty-year follow-up! In the past relapses and recurrences have been common. Osteomyelitis, like tuberculosis, is arrested not eradicated. Dr R. I. Harris has said that he is now treating patients with osteomyelitis

at the General Hospital whom he had cured twenty-five years ago at the Sick Children's. But the future looks bright. Certainly sequestration, sinus formation, and early flare-ups have been far less common than they used to be, and involvement of more than one bone is comparatively rare.

To those who have seen osteomyelitis in the bad old days, the complete change in the clinical course of these patients and the reduction in mortality from 20 per cent to 1 or 2 per cent is one of the most heartening advances of modern surgery. F. R. WILKINSON.

PROTRUSIONS OF THE LUMBAR INTERVERTEBRAL DISCS *

A Clinical Review Based on Five Hundred Cases Treated by Excision of the Protrusion

JOHN E. A. O'CONNELL, LONDON, ENGLAND

From the Department of Neurosurgery, St Bartholomew's Hospital, London

Though lumbago and sciatica carry little threat to life, they may interfere greatly with living. Their frequency and their annual toll of suffering and disability have been a constant stimulus to investigation. The discovery by Mixter and Barr in 1934 that an intraspinal protrusion of a lumbar intervertebral disc was sometimes the cause of these troubles was outstandingly important, for it not only provided a rational basis for treatment but also led to the careful investigation in hospital of large groups of these patients, with a further growth in knowledge. That lumbago and pain in the lower limb are essentially subjective disturbances makes for certain difficulties in reviewing a series of cases, particularly in assessing the results of treatment. When the present investigation was planned it was considered that the difficulty might be lessened if the case records were made by the individual who would subsequently review them. In every case, therefore, at least one pre-operative examination and a number of post-operative examinations were made by the author. Further, all cases in the series were operated upon by him—except a few in which he assisted his registrar. The operative findings were immediately recorded. These constitute the records which have been analysed, and they belong to 500 cases of proven lumbar intervertebral disc protrusion operated upon between January 1938 and May 1948 at St Bartholomew's Hospital. The purpose of the investigation has been: firstly, to crystallize our experience with cases of low back and lower limb pain; and secondly, to determine the results of excision of intervertebral disc protrusions in a large group of patients observed for an adequate period after operation.

SEX AND AGE INCIDENCE

There were 330 males (66 per cent) and 170 females (34 per cent). That males were affected twice as often as females is doubtless related to the heavier nature of their work. The age distribution is shown in Figure 1. The youngest patient was aged sixteen years and the oldest fifty-eight years. Most were in the fourth decade and almost three-quarters were between the ages of twenty-one and forty.

PATHOLOGY

It is necessary first to consider briefly how lumbar intervertebral disc protrusions produce their characteristic clinical picture. The posterior common ligament and the annulus fibrosus of the intervertebral disc are supplied with sensory nerve fibres. Low back pain may be the consequence of: a tear of either structure, as in other sprains; stretching of the torn ligaments by the protruding nucleus pulposus, aggravated by postures and movements which increase the considerable pressure within it; and possibly the abnormal stresses developed in the muscles, ligaments and synovial [diarthrodial] joints of the lumbar spine in consequence of the injury to one of the large symphysial joints between the vertebral bodies. The lower

* A Hunterian lecture given at the Royal College of Surgeons of England on February 16, 1950.

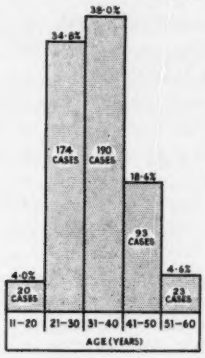

FIG. 1

Histogram showing the age distribution among 500 patients operated upon for protrusions of intervertebral discs.

limb symptoms and signs are caused by compression and stretching of the nerves of the cauda equina, or sudden injury of them, by the protruded disc. Three circumstances may obtain: 1) If a large mass of disc tissue enters and fills the spinal canal all the contained nerve roots will be compressed (Fig. 2). 2) In the more usual type of protrusion a relatively small mass of disc tissue enters the spinal canal and becomes intimately related to one anterior and one posterior spinal nerve root between their point of emergence from the dural theca and their entrance into an intervertebral foramen. In this part of their course, where the two roots together constitute an *extradural intraspinal nerve* they are invested by a dural sheath. Unlike the dural theca, which with its contained nerve roots is readily displaced by a protruded disc, the extradural nerve with its strong dural sheath is relatively taut, and a small protrusion—or even strong adhesions between this nerve and the intervertebral disc—

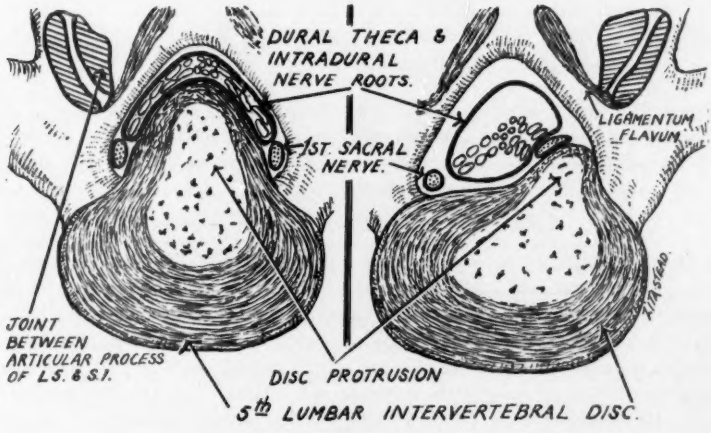

FIG. 2

Diagrams of sections through the lumbo-sacral intervertebral disc. In the drawing on the left a large central disc protrusion is shown. That on the right shows the more common lateral protrusion with the first sacral nerve stretched over it.

may sufficiently increase the tension within it to cause pain. Even if the protrusion is large enough to displace the nerve backwards against the vertebral lamina it is believed that tension remains the important factor, since, without it, the nerve would be displaced like the theca and its contents. 3) Sometimes the displacement of a large mass of disc tissue is sudden: the roots of the cauda equina suffer an acute injury and the clinical picture of a severe lesion of the lower lumbar and sacral roots is at once established. Review of the operative findings in 350 cases of this series suggests that the clinical picture was caused by compression alone in 1 per cent, by tension alone in 31 per cent, by a combination of stretching and compression in 66 per cent, and by sudden injury to the cauda equina in 2 per cent.

TABLE I

ETIOLOGICAL FACTORS IN 500 CASES OF INTERVERTEBRAL DISC PROTRUSION TREATED BY OPERATION

Etiological factor	No. of cases	%
Injury	295	59·0
Pregnancy and labour	29	5·8
Physical weakness after illness or operation	6	1·2
No etiological factor discovered	170	34·0
Total	500	100

Nature of injury	%
Lifting (including digging)	52
Fall (usually on the feet or buttocks)	33
Direct injury to back	8
Twisting movements	7

Occupation of patient	%
Heavy manual work (237 patients)	47·4
Armed forces (182 patients)	36·4
Sedentary work (60 patients)	12·0
Not recorded (21 patients)	4·2

CAUSATIVE OR PREDISPOSING FACTORS

The factors thought to cause or contribute to the lumbar disc protrusion are analysed in Table I. The importance of a definite and remembered injury is clear. Pregnancy and labour were responsible factors in 17 per cent of the female patients. It has been suggested (O'Connell 1944) that the corpus luteum hormone, which causes relaxation of the ligaments surrounding the pelvic joints, might also affect the lumbar intervertebral joints, so that they may become more vulnerable to the ordinary physical stresses of life as well as to the extraordinary stresses associated with child-bearing. The development of symptoms immediately after recovery from anaesthesia or during convalescence suggests that the reduced muscular tone present at such times may predispose to intervertebral disc injury. The type of causative injury was determined from the records of 123 patients from whom exact information was obtained:

in 85 per cent the injury was sustained either in lifting some heavy weight or in falling. The occupations of 84 per cent of the patients caused physical stress. Anyone unaccustomed to such stresses was perhaps more likely to sustain intervertebral disc injury, and the high proportion of Service patients in the series may perhaps be so explained.

CLINICAL FEATURES

The distribution of pain is analysed in Table II. In most patients low back pain and lower limb pain were present together. In 13 per cent pain occurred in the lower limb alone: in only one patient was it confined to the lumbar region. This does not imply that lumbar disc protrusions seldom cause low back pain without sciatica: on the contrary many patients with sciatica in whom a protrusion is ultimately found at operation have a history of one or more previous attacks of localised low back pain. The correct inference from our experience

TABLE II

DISTRIBUTION OF PAIN IN 500 CASES OF INTERVERTEBRAL DISC PROTRUSION TREATED BY OPERATION

Distribution	No. of cases	%
Lumbar spine and lower limb	434	86·8
Lower limb only	65	13·0
Lumbar spine only	1	0·2
Total	500	100

Side involved in cases of lower limb pain	No. of cases	%
Left side	260	52·0
Right side	195	39·0
Bilateral	31	6·2
Alternating	13	2·6
Total	499	99·8

is that back pain from a disc protrusion is seldom so severe, so persistent or so frequent as to require operation. Occasionally, pain affected both lower limbs either simultaneously or in succeeding attacks. In over 90 per cent, however, it was felt in one leg alone, and the left was involved more often than the right in the proportion of 1·3: 1. Others have related this left-sided preponderance to right-handedness. No evidence has been found to support this hypothesis. But the fact that the side of the master hand may not correspond to that of the foot preferred in games, etc., may explain the absence of any such obvious correlation. Certainly it seems that when the lumbar spine is subjected to stress the protective mechanism is less complete on the left than on the right in a significant proportion of individuals. The lower limb pain was posterior (sciatic) in 98 per cent of the patients, and anterior—with or without sciatic pain—in 2 per cent. A careful determination of the peripheral radiation of the pain is important in localising the affected disc: involvement of the heel, sole and outer margin of the foot points to a lumbo-sacral disc lesion; radiation to the dorsum of the foot and hallux suggests protrusion of the disc between the fourth and fifth lumbar vertebrae; and anterior thigh pain radiating across the patella and along the antero-medial surface of the leg points to a lesion at the L.2–3 or L.3–4 interspace.

In Tables III, IV, and V the number of pre-operative attacks of pain, and the total duration of symptoms are recorded. It is noteworthy that one attack of sciatica may persist for as long as five years; that the interval between two severe attacks may be twenty years; and that attacks may recur over a period of twenty-five years. The total duration of symptoms was one year or less in approximately one-third of the patients, and over one year in the remaining two-thirds. Table V shows the duration of the pre-operative attack of pain. This was one year or less in almost three-quarters of the patients and over one year in the remainder. In Table VI the frequency of symptoms other than pain is noted. Paraesthesiae in the lower limb were very common; their peripheral distribution has the same localising significance as

TABLE III

NUMBER OF PRE-OPERATIVE ATTACKS OF PAIN

Number of attacks	No. of cases	%
One attack only	252	50·4
Two attacks	76	15·2
Three or more attacks	172	34·4
Total	500	100

that of the pain. Twenty-one patients (4·2 per cent) complained of severe weakness in one or both legs; in five of these the picture was one of a severe cauda equina lesion with the characteristic motor, sensory and sphincter disturbances; in the remainder it involved one lower limb only, where dorsiflexion and eversion of the foot and extension of the toes were particularly affected. Severe disturbance of vesical control was limited to the five patients with the cauda equina syndrome. In five others, however, increased frequency or difficulty of micturition developed in association with the sciatic pain.

The investigation of the patient must include a thorough general examination and a digital examination of the pelvis. Clinical signs due to an intervertebral disc protrusion fall into

TABLE IV

TOTAL DURATION OF SYMPTOMS

Duration	No. of cases	%
Less than six months	94	18·8
Six to twelve months	88	17·6
Over one year	318	63·6
Total	500	100
Duration over five years in 114 cases (22·8%)		

three groups—spinal, tension and neurological signs. The spinal and tension signs supply information concerning the size of the protrusion and its relationship to the extradural nerve and theca. They are especially valuable in assessing the severity of the patient's pain. The neurological signs indicate the severity of the injury to nerve fibres and assist greatly in determining which extradural nerve—and therefore which intervertebral disc—is affected.

The spinal signs are analysed in Table VII. Reduced mobility is probably always present; flexion is often greatly restricted. In only nine cases was spinal movement but slightly impaired, and in two of these the protrusion was in the upper lumbar region. Hyperextension

TABLE V

DURATION OF ATTACK OF PAIN IMMEDIATELY BEFORE OPERATION

Duration	No. of cases	%
Less than six months	225	45·0
Six to twelve months	140	28·0
Over one year	135	27·0
Total	500	100

TABLE VI

SYMPTOMS OTHER THAN PAIN

Symptoms	No. of cases	%
Paraesthesiae	350	70·0
Gross loss of power in one or both lower limbs	21	4·2
Disturbance of vesical control	10	2·0

TABLE VII

SPINAL SIGNS

Signs	No. of cases	%
Reduced mobility	500	100
Deformity: *Diminished lumbar curve or lumbar kyphosis*	411	82·2
Lumbar scoliosis { *Convex to side of pain* 73% / *Concave to side of pain* 17% / *Alternating* 10% }	244	48·8
Tenderness { *Localised to level and side of lesion* 81% / *With radiation of pain to affected limb* 19% }	391	78·2

TABLE VIII

TENSION SIGNS

Signs	No. of cases	%
Positive straight leg raising test (*At angle greater than* 75° 25%) (*At angle less than* 75° 75%)	495 (Test negative in five patients, all with upper lumbar disc protrusion)	99
Positive drop test	Most cases in which straight leg raising was restricted	
Positive femoral nerve stretch test	All cases of protrusion of L.2–3 and L.3–4 discs	
Positive neck flexion test or Naffziger's test	Many cases	

is frequently painful, particularly when the protrusion affects one of the upper lumbar discs. Attempts to correct a lateral tilt often produce pain in the affected lower limb. Lumbar tenderness at the level of the protrusion was seen in almost 80 per cent of the patients. In a quarter of these pressure at the most tender point caused pain to radiate into the lower limb. Deformity was present in over 80 per cent of cases; reduction of the normal lumbar lordosis was most frequent, sometimes amounting to a lumbar kyphosis. Lumbar scoliosis was seen in almost 50 per cent of cases; the convexity was usually towards the painful limb, but sometimes away from it. Occasionally it could be made to alternate. A particular posture or deformity is probably adopted to lessen the painful stretching and compression of the extradural nerve. In certain postures the pressure exerted by body weight on the affected intervertebral disc will be reduced, with consequent diminution in the size of its protruded part. It is probable also that the relationship of the extradural nerve to the protrusion is varied by alterations in spinal posture; possibly displacement of both protrusion and extradural nerve may give rise to such variation in relationship. In the common type of

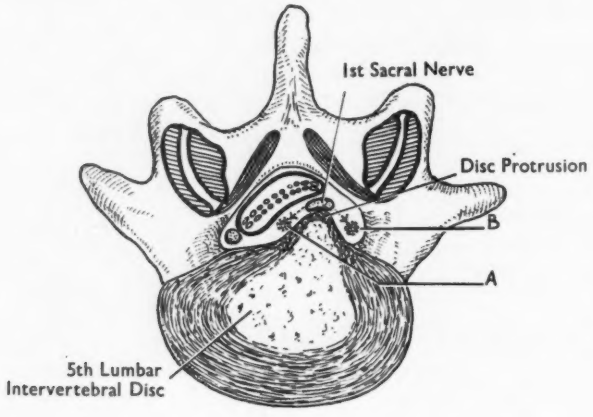

FIG. 3

Diagram of a section through the lumbo-sacral intervertebral disc. It is believed that when the extradural nerve lies on the summit of the protrusion pain is greatest and that when it is displaced to the medial or lateral side of this summit pain is reduced. Thus may be explained the occurrence of an alternating scoliosis.

protrusion, with its summit lateral to the nerve, the lower lumbar scoliosis is convex to the painful side. Such a posture may serve to separate the nerve from the summit of the protrusion and thus diminish lower limb pain. With the less common type of protrusion, lying medial to the extradural nerve, the scoliosis is frequently concave to the painful side, and perhaps here the deformity again serves to reduce pain by separating the nerve from the summit of the protrusion. The relationship of the protrusion to the extradural nerve can often though not always be predicted before operation on the basis of this hypothesis. Further, in patients with an alternating scoliosis it has been repeatedly observed that pain is greatest when the scoliosis is corrected and is relieved with a tilt to either side. Operation in these cases has almost always revealed a freely mobile nerve and a protrusion with a trough on each side of its summit (Fig. 3). When pain is greatest and the spine straight, the extradural nerve lies on this summit; when there is a lateral tilt in one direction or the other it lies in either the medial or the lateral trough.

The tension signs are indicated in Table VIII. The normal state of tension in the lumbar extradural nerve has already been emphasized as an important cause of symptoms. The relevant signs depend upon increase in this tension by a lumbar disc protrusion: certain positions of the head, trunk and limbs, and alterations in cerebro-spinal fluid pressure, which further increase this tension, so aggravate the pain. These signs are of value not only in determining the presence and relationships of a lumbar disc protrusion but also in assessing the severity of the pain (O'Connell 1943, 1946). From dissection in the cadaver it has been found that flexion of the head and neck produces a cephalad movement of the dural theca and the consequent increase in the tension in the extradural nerves within the spinal canal, particularly the longitudinally disposed lumbar and sacral nerves. In the same way it has been observed that when the hip is fully flexed, with the knee extended and the ankle dorsiflexed, a caudal movement of the theca occurs and tension in the extradural nerves entering the sacral plexus is at its greatest. The extradural nerves entering the femoral nerve (second, third and fourth lumbar nerves) are made tense not by this manoeuvre but by extension of the hip and flexion of the knee. Thus is explained the basis of the straight leg raising and femoral nerve stretch tests (Fig. 4). During operations upon the lumbar spine in the lateral position these findings have been confirmed. Further, it has been noted that with jugular compression the theca swells and the upper attachment of the extradural nerve is carried laterally — its lower extremity remaining fixed in the intervertebral foramen. In the common relationship in which the protrusion is lateral to the extradural nerve, this movement will frequently increase the pain. Occasionally jugular compression relieves the pain and in such cases the extradural nerve is usually found to be lateral to the summit of the protrusion. Similarly neck flexion often aggravates the pain of a lateral protrusion because it draws the nerve towards the highest part of the mass. With a medially placed protrusion neck flexion has the effect of displacing the nerve to a lower part of the mass and may relieve the pain (Fig. 5). Neck flexion and jugular compression therefore assist, as does the nature of a scoliosis, in determining the relationship of nerve to protrusion. When these manoeuvres alone do not influence the pain it will frequently be found that they do so if

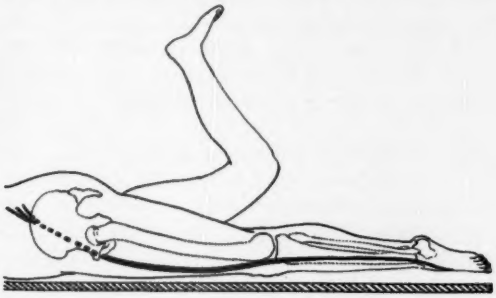

FIG. 4

Representation of the femoral nerve stretch test, which is of value in the diagnosis of upper lumbar disc protrusions.

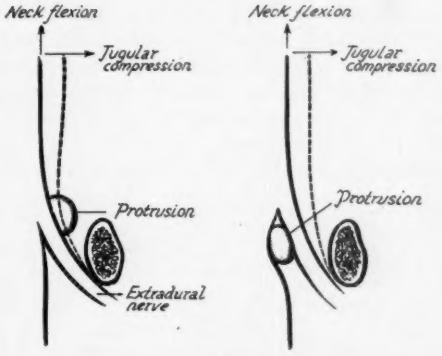

FIG. 5

Diagram to indicate the value of neck flexion and jugular compression in the clinical determination of the relationship of protrusion to extradural nerve. On the left is shown a lateral protrusion, and since either neck flexion or jugular compression displaces the nerve towards its summit each increases the pain. On the right is a medially placed protrusion; either procedure will displace the nerve from the protrusion and thus diminish pain.

TABLE IX

NEUROLOGICAL SIGNS

Signs	No. of cases	%
Motor	**480**	**96·0**
Atrophy and hypotonia in territory of affected motor root or roots	475	95·0
Slight weakness of extensors or flexors of digits	146 (*of* 198 *tests recorded*)	74·0
More severe weakness—paraparesis	32	6·4
Sensory	**403**	**80·6**
Hypoalgesia and hypoaesthesia or anaesthesia	396	79·2
Hyperaesthesia	7	1·4
Reflex		
Normal	110	22·0
Abnormal	**390**	**78·0**

combined with straight leg raising. When it has been found difficult to assess the severity of pain, and when there has been doubt at what angle straight leg raising aggravates it, the drop test has been found of value. In cases of lower lumbar disc protrusion both straight legs can frequently be raised together to a higher angle, without causing pain, than can the limb on the painful side alone. If this is done and the sound limb is allowed to drop on to the bed, a well-marked increase in pain will often testify to increased tension in one of the extradural nerves entering the sacral plexus. It has been suggested in the literature that straight leg raising increases crural pain by movement of the lumbar vertebrae. That this is relatively unimportant may be demonstrated by obliterating the lumbar curve by fully flexing the hip and knee on the sound side; the angle at which the straight leg raising test then aggravates the pain is little changed.

The neurological signs are indicated in Table IX. Motor disturbance was seen in 96 per cent,

TABLE X

ANALYSIS OF REFLEX DISTURBANCE

	No. of cases	%
L.5–S.1 protrusions (248 cases):		
reflexes normal	36	14·5
ankle jerk reduced or absent	211	85·0
knee jerk reduced or absent	7	2·8
L.4–5 protrusions (198 cases):		
reflexes normal	68	34·0
ankle jerk reduced or absent	129	65·1
knee jerk reduced or absent	10	5·0
Double protrusions (46 cases):		
reflexes normal	6	13·0
ankle jerk reduced or absent	38	82·6
knee jerk reduced or absent	3	6·5
L.2–3 and L.3–4 protrusions (8 cases):		
reflexes normal	nil	—
ankle jerk reduced or absent	6	75·0
knee jerk reduced or absent	4	50·0

sensory disturbance in 80·6 per cent, and reflex disturbance in 78 per cent. Taken in conjunction with the radiographic findings these signs are of first importance in determining the particular disc affected. Motor disturbance contributed least information but sensory and reflex changes were of great value. Thus sensory impairment on the sole and outer margin of the foot (first sacral dermatome) with absence of the ankle jerk pointed to a lumbo-sacral disc protrusion; sensory impairment on the dorsum of the foot (fifth lumbar dermatome) without alteration of the ankle jerk suggested a protrusion of the L.4–5 disc; and impairment of sensibility extending from the patella along the antero-medial surface of the lower leg, with reduction of the knee jerk, pointed to a protrusion of one of the upper lumbar discs (L.2–3 or L.3–4).

The state of the tendon reflexes in the lower limbs is shown in Table X. Normal tendon reflexes were never seen in the presence of an upper lumbar disc protrusion. They were normal more often when the protrusion affected the L.4–5 disc than when the lumbo-sacral or both the lower lumbar discs were involved. Reduction or absence of the ankle jerk was usually associated with a lumbo-sacral protrusion but was common with protrusions at all

TABLE XI

ACCESSORY METHODS OF DIAGNOSIS

	No. of cases	%
Radiographic examination of spine (Adequate radiographs available in 469 cases)		
Findings indicating presence and level of protrusion	265	57
Findings doubtful	87	18
Findings negative	117	25
Lumbar puncture (41 cases):		
Complete subarachnoid block	5	12
Increased C.S.F. protein concentration	31	76
Myelography (40 cases):		
Iodized oil (24 cases): positive findings	17	70
Oxygen (16 cases): positive findings	5	31

levels. Absence or reduction of the knee jerk was most common with protrusion of one of the upper lumbar discs but also occurred, in diminishing frequency, with double protrusions, with protrusions of the L.4–5 disc, and with lumbo-sacral protrusions. Although pain is caused by stretching or compression of one intraspinal extradural nerve, impairment of the ankle jerk in cases of high lumbar protrusion and of the knee jerk in cases of low lumbar protrusion nevertheless suggests that injury to *intrathecal* nerve roots plays a part in the development of the neurological picture.

RADIOGRAPHIC EXAMINATION

Table XI indicates the results of radiographic examination in 469 cases of the series in which adequate information concerning these results was available at the times of the follow-up investigations. Good lumbar and sacral radiographs must be made in every case. They may at once reveal some other responsible lesion such as an intraspinal neoplasm, a primary or

secondary vertebral growth or tuberculous spondylitis. Secondly, the spinal films may indicate the presence and level of the protrusion by showing narrowing of an intervertebral space with sclerosis of the adjacent vertebral surfaces and perhaps lipping of their margins (Fig. 6). Thirdly the films may show congenital variations in the lumbo-sacral region which are important in the localisation of the affected disc on the basis of neurological signs. It is believed that sacralisation of the fifth lumbar vertebra is more common than is usually stated. When there are only four lumbar vertebrae or when massive fifth lumbar transverse processes are partly fused with the sacrum the abnormality is obvious. Far more common is a condition—which may be called "occult sacralisation"—in which there are five lumbar vertebrae but the last is placed high so that its spine is at or just below the level of the iliac crests, the sacrum is long with perhaps five instead of four foramina, and the last rib is much longer than the true twelfth rib. Here it may well be that the apparent first lumbar vertebra is in reality the last dorsal, and the true fifth lumbar vertebra is fused with the sacrum. Recognition of this abnormality has frequently explained why a protrusion of the last intervertebral disc may give rise to the clinical picture of a protrusion of the disc between the fourth and fifth lumbar vertebrae. There were fifty cases of sacralisation of the fifth lumbar vertebra (10 per cent) and it is noteworthy that its recorded incidence is higher among the later cases in the series.

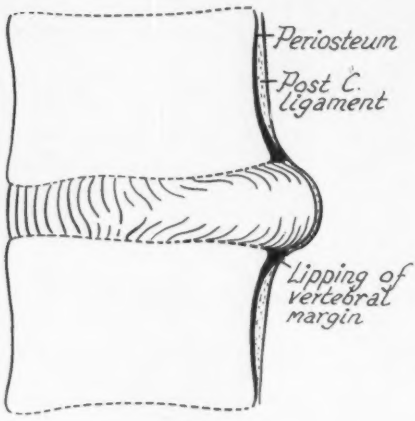

FIG. 6

Possible explanation of marginal lipping adjacent to a disc protrusion. The posterior longitudinal ligament, displaced and tautened by the bulging disc, pulls upon the attachment of the periosteum to the posterior vertebral margins; new bone forms beneath the periosteum at the points of tension.

ACCESSORY METHODS OF DIAGNOSIS

Lumbar puncture (41 cases), and *myelography* with lipiodal or oxygen (40 cases), which were performed as a routine in the early cases are now used only in atypical ones and, in particular, when a neoplasm is suspected (Table XI). A clinical diagnosis of a lumbar intervertebral disc protrusion is considered more accurate than a myelographic one. The diagnosis is readily made in most patients by a careful clinical and radiographic examination.

SELECTION OF CASES FOR OPERATION

The greatest problem is not diagnosis but deciding upon the correct treatment in each case. The natural history of lumbago and sciatica has not been altered by the discovery of their common cause, and the tendency to spontaneous recovery remains as strong as it has been down the centuries. Rest during the stage of acute symptoms, with later exercises for the lumbar muscles and joints, forms the correct treatment in most patients. Only when an adequate trial of such measures fails to bring relief should surgery be considered. It is therefore clear that any discussion of the relative merits of conservative and surgical treatment is profitless, because surgery should be reserved for cases in which other measures fail. This series of 500 patients treated surgically represents but a small proportion of the patients seen in the out-patient department in whom a clinical diagnosis of protruded lumbar intervertebral

disc has been made. It is difficult to determine what proportion of patients with disc protrusions require operation. Before a patient attends a neurosurgical clinic he will have been seen by a general practitioner and often also by a general physician, a neurologist or an orthopaedic surgeon: many of the milder cases are so filtered off and never reach the neurosurgeon. Of the patients referred to the neurosurgical out-patient clinic at St Bartholomew's Hospital, less than 20 per cent are submitted to operation. The only absolute indication for operation is the sudden development of severe neurological disturbance from involvement of the cauda equina by a large protrusion. This clear indication for surgery was present in 2 per cent of our cases; in the remainder the operative indications were relative. Important factors are the severity and duration of pain and the frequency of recurring attacks. The severity of the pain is assessed from the history, from the tension signs and from the degree of disability. When these suggest that the emotional accompaniment of pain is excessive and that the symptom is one of discomfort or aching rather than pain, operation is avoided. Operation is seldom undertaken unless the duration of symptoms exceeds three months. But if pain is intense or if short sharp attacks recur at brief intervals this arbitrary minimum period of conservative treatment may be shortened.

AIMS AND TECHNIQUE OF OPERATION

In operating there are three objects. The first is to remove the protruded fragments of disc. If there are well-marked projections of the vertebral margins above and below the protrusion these are removed at the same time. (In Figure 6 a possible explanation of the

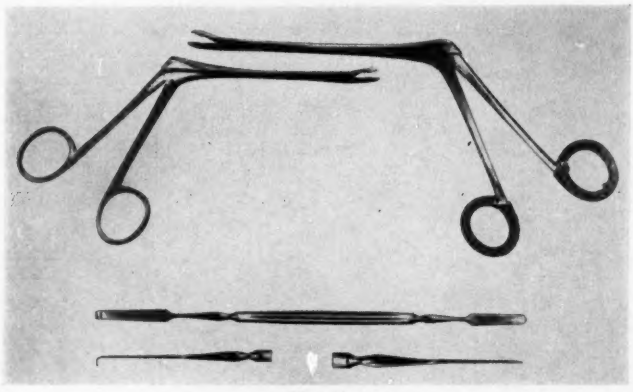

FIG. 7

Nerve retractor and (*above*) pituitary rongeurs used in the removal of intervertebral disc protrusions.

development of this lipping is illustrated.) Secondly, adhesions between the nerve and the posterior longitudinal [common] ligament or the annulus fibrosus are divided to reduce the tension within the nerve as much as possible. Thirdly, an effort is made to clear the intervertebral interval of as much disc tissue as possible to lessen the risk of recurrence.

The development of the operation, in our hands, is indicated in Figures 8 to 11. In the first four cases the protrusion was removed by the transdural route after wide laminectomy (Fig. 8). Subsequently the exposure was extradural in all cases and the amount of bone removed was gradually reduced until, after seventy-five operations, a single spinous process and the related lamina on the side of the lesion were alone removed (Fig. 9). Our present technique was developed after 130 cases had been dealt with. The exposure is limited to stripping the

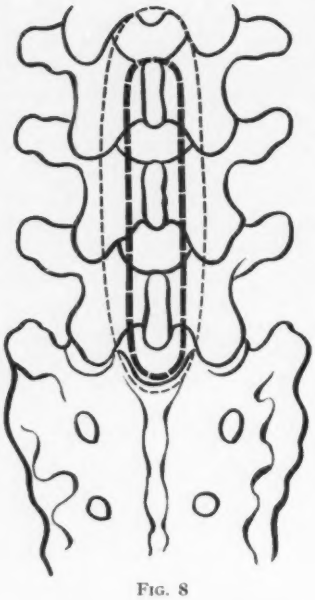

FIG. 8

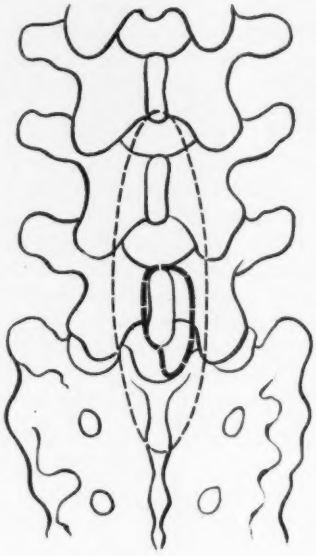

FIG. 9

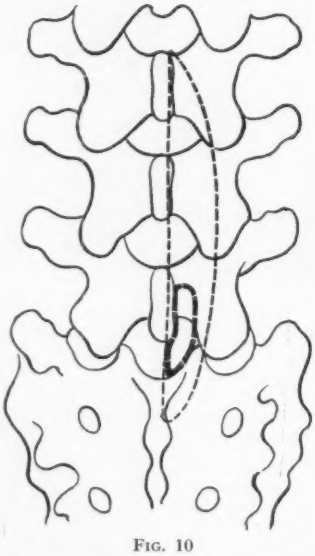

FIG. 10

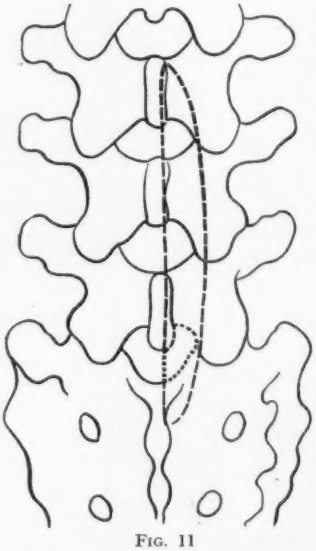

FIG. 11

Evolution of the exposure used in excision of intervertebral disc protrusions. Figure 8, wide laminectomy; transdural approach. Figure 9, removal of one spinous process and one lamina after bilateral stripping of spinal muscles. Figure 10, unilateral stripping of muscles and incomplete removal of one lamina with the ligamentum flavum caudal to it. Figure 11, interlaminar approach without removal of bone.

muscles from the vertebral spinous processes and laminae on the side of the lesion and excising part of the lower margin of the lamina of the vertebra above the interval to be explored (Fig. 10). If the interval between the laminae is wide it may be unnecessary to remove any bone (Fig. 11). The stages of the operation are shown in Figures 12 to 19, and some of the instruments in Figure 7. When there is any doubt as to the adequacy of the operative findings at a particular level the adjacent disc is explored in the same way. Exposure of two or more levels was undertaken in 21·8 per cent of cases. If the patient has had well-marked bilateral pain of some duration the affected disc is exposed by an approach similar to that described above but on both sides: although most of the disc contents can usually be removed through a unilateral exposure, adhesions on the opposite side would be left undivided and might lead to persistent symptoms on that side. Posterior rhizotomy was performed in only two patients,

TABLE XII

FINDINGS AT OPERATION

	No. of cases	%
Level of protrusion		
True L.5–S.1	248	49·6
True L.4–5	198	39·6
Double protrusion	46	9·2
Upper lumbar protrusions (L.2–3, L.3–4)	8	1·6
Total	500	100
Type of lesion (Review limited to the last 400 cases in the series)		
1. Protrusion without ligamentous covering	50	12·5
2. Large protrusion with thin ligamentous covering	259	64·7
3. Small protrusion (revealed by abnormality of posterior common ligament, etc.)	91	22·8
Total	400	100
Explorations at which no protrusion was revealed (18 in 518 operations (3·4%)		
Other lesion discovered	5	
Neurofibroma of cauda equina . 1 case		
Tuberculous spondylitis . 2 cases		
Spondylolisthesis . 1 case		
Cyst of nerve sheath . 1 case		
Negative explorations	13	
? osteoarthritis of spine . 4 cases		
? spina bifida occulta . 2 cases		
Total	18	3·4

both of whom had recurrent protrusions. In no case was a spinal fusion done: we have, however, a small group of patients not included in the present series in whom a combined exploration and fusion was undertaken with an orthopaedic colleague. These patients complained of backache only and it was considered clinically that they were unlikely to benefit from intervertebral disc surgery—an impression which was confirmed by the operative findings in each instance.

Post-operative treatment—After operation the patient is encouraged to move freely in bed, and he usually gets up on the eighth post-operative day. Spinal exercises are begun on the tenth day and most patients are discharged, able to touch their toes, three weeks after operation. All are instructed to continue regular spinal exercises—a routine that we consider most important.

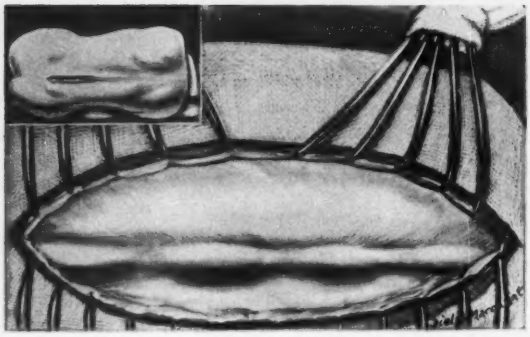

FIG. 12

FIG. 13

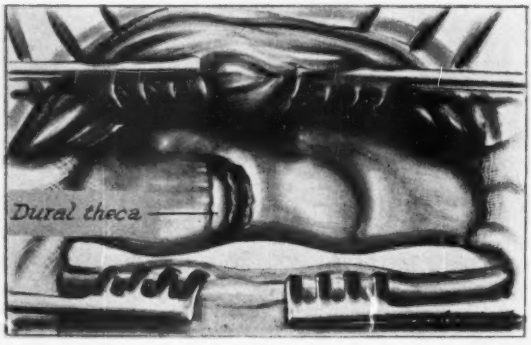

FIG. 14

Technique of operation for excision of lumbo-sacral disc protrusion. Figure 12, the incision; inset shows position of patient. Figure 13, the sacrospinalis (erector spinae) mass is separated subperiosteally from the upper sacral and lower lumbar spines and laminae on the side of the lesion. Figure 14, the lower part of the fifth lumbar lamina is excised on the side of the lesion. Note the deep self-retaining retractors.

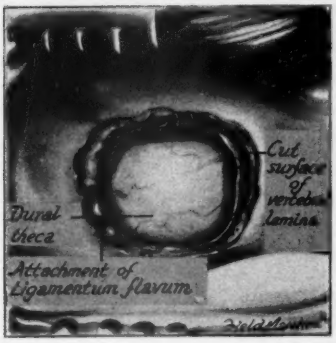

FIG. 15

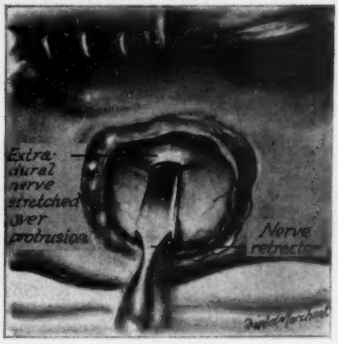

FIG. 16

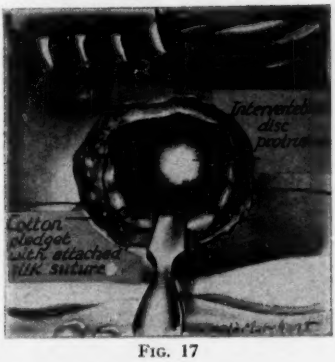

FIG. 17

FIG. 18

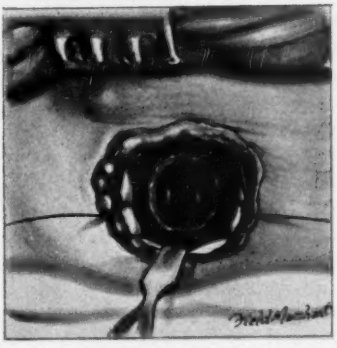

FIG. 19

Figure 15, the ligamentum flavum is resected and the dural theca exposed. Figure 16, the extradural nerve crossing the protrusion is displayed. Figure 17, retraction of the extradural nerve and theca reveals dome of protrusion covered by posterior longitudinal ligament. Figure 18, the ligament is incised and disc tissue escapes under pressure. Figure 19, the protrusion has been excised and the intervertebral interval has been cleared of disc tissue as completely as possible.

FINDINGS AT OPERATION

The operative findings are shown in Table XII. The lesion was usually found at either the fourth or the fifth lumbar disc—lumbo-sacral disc protrusions being the more common. It is noteworthy that in the ten-year period during which the 500 operations for lumbar intervertebral disc protrusions were performed, seven cervical and three thoracic [dorsal] disc protrusions were excised. The relatively great size of the lumbar intervertebral discs and their position in a mobile region of the spine, which is subjected to greater stresses in weight-bearing and on movement than any other, together no doubt explain the greater frequency with which the lumbar disc protrusions demand operation.

While it is agreed in the literature that the last two lumbar discs are those usually involved, in some series the lumbo-sacral disc has been the one most frequently affected and in others the disc between the last two lumbar vertebrae. In the present series it was found that the last lumbar disc was the site of the protrusion in 60 per cent and the disc above this in 30 per cent. However, this statement does not indicate accurately the true level of the

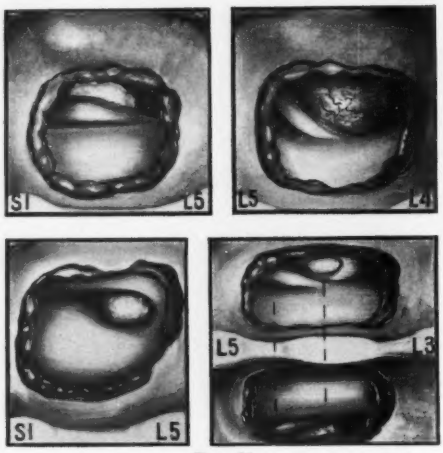

FIG. 20

Types of lesion encountered. *Above, left*—a protrusion which has penetrated the posterior longitudinal ligament. *Above, right*—a small protrusion revealed by vascularisation and loss of lustre of the posterior longitudinal ligament, and by adhesions between it and the extradural nerve. *Below, left*—a medial protrusion presenting in the axilla of the extradural nerve. *Below, right*—bilateral exposure in a case of persistent bilateral sciatic pain. On the left side a protrusion has penetrated the posterior longitudinal ligament. On the right side there are adhesions between the nerve and the ligament.

protrusion. It has been mentioned previously that sacralisation of the fifth lumbar vertebra, especially of a hidden type, occurs with some frequency. It was considered that in fifty cases of protrusion of the last intervertebral disc this disc was not anatomically the lumbo-sacral disc but that between the fourth and fifth lumbar vertebrae. Allowing for this correction the incidence of protrusion of the disc between the fifth lumbar and first sacral vertebrae falls to 50 per cent and that of the disc between the fourth and fifth lumbar vertebrae rises to 40 per cent.

In Table XII the type of lesion found is classified in terms which facilitate its recognition and description (see also Fig. 20). The large protrusions with or without a ligamentous

covering should be recognised easily, though care is necessary not to overlook those placed medially beneath the theca. A thorough exploration in a bloodless field is required to reveal the small protrusions. Here there may be little or no intraspinal projection of disc tissue to be seen at operation, but the extradural nerve may be adherent to the posterior longitudinal ligament: this structure has lost its usual lustre or may be roughened by adhesions, and groups

FIG. 21

Typical specimen of intervertebral disc material removed at operation. Weight 2·9 grammes.

of small new blood vessels may be present in it. Sometimes a soft spot in the underlying annulus fibrosus may be palpated. These findings probably indicate a healed or healing stage of a severe injury to the posterior longitudinal ligament and annulus, and tension-producing adhesions between nerve and ligament are frequently the only obvious cause of the symptoms. Excellent results may follow the treatment of this lesion, which has been called the "concealed disc." The term is an unfortunate one: it is surely better to indicate how a particular type of protrusion may be recognised than to suggest to the surgeon that it may be hidden from him—a suggestion that may lead to an unwarranted attack on faultless intervertebral discs.

Weight of disc tissue removed—It has been found valuable to record routinely the weight of the disc tissue removed. At post-operative follow-up examinations the figure tells something of what was accomplished at operation. It is important to weigh the specimen without immersion, which even for a short period considerably increases the weight. Thus the average weight of the seventy-six specimens of disc tissue before immersion in fixative was 1·95 grammes; after fixation in formol-saline for twenty-four hours the average weight was 3·14 grammes—an increase of 60 per cent. The specimens of ligamentum flavum removed at these operations were weighed as controls, and it was found that the average weight before immersion was 0·57 grammes and that after fixation 0·63 grammes—an increase of 11 per cent. These observations suggest that after its escape from within the annulus fibrosus the turgid nucleus pulposus loses fluid into the extradural space—a loss which may be important in diminishing the size of the protrusion. In a series of 350 specimens the weight before immersion was less than 1 gramme in 14 per cent; 1–2 grammes in 32 per cent; 2–3 grammes in 31 per cent; 3–5 grammes in 21 per cent; and over 5 grammes in only 2 per cent. The average weight of a series of lumbar intervertebral discs excised *completely* at autopsy was 24·6 grammes. Thus only exceptionally does the specimen removed at operation represent more than 20 per cent by weight of the average normal intervertebral disc, although in the present series an effort was always made to remove not only the protrusion but as much as possible of the undisplaced disc tissue (Fig. 21). The average total weight of a series of lower cervical discs removed at autopsy was just under 1 gramme—only 4 per cent of the weight of a lumbar disc. This may explain why root symptoms from a cervical disc protrusion seldom persist, whereas with the larger lumbar discs persistence of such symptoms is relatively common.

During the period of this investigation, when 500 disc protrusions were removed, eighteen explorations (3·4 per cent) were undertaken without finding a disc protrusion. These cases are analysed in Table XII. In five patients another cause for the symptoms was discovered. The remaining thirteen operations (2·5 per cent) are classified as negative explorations, but spina bifida occulta was present in three and osteoarthritis of the spine in four, and these conditions may have had a bearing on the symptoms. Thus only in six cases was no adequate lesion revealed. It is noteworthy that seven of the thirteen negative explorations occurred in the first twenty-six patients treated surgically.

MORTALITY

There were two post-operative deaths in the series—a mortality rate of 0·4 per cent. The first was in a man of fifty-six years with pulmonary and urogenital tuberculosis. He developed a urinary and pulmonary infection and a late wound infection, and died nineteen days after operation. The second death was in a man of thirty years who developed abdominal pain and rigidity six days after operation. The abdomen was explored but no cause for the symptoms was found; he died on the tenth day. At autopsy an acute osteomyelitis of the second and third dorsal vertebrae with related extradural pus was discovered. The connection between this and the operation was not clear though it seems possible that the vertebral disease was due to an infective venous thrombosis from the site of operation. Up to the end of 1949 a further 118 patients had been operated upon without a death, making a mortality rate of 0·32 per cent for 618 cases.

TABLE XIII

POST-OPERATIVE COMPLICATIONS

	No. of cases	%
Wound infection	15	3·0
Haematoma formation (superficial)	10	2·0
Pulmonary complications	5	1·0
Retention of urine (12–48 hours)	infrequent	—
Post-operative pain in back and groin	8	1·6

COMPLICATIONS (TABLE XIII)

Retention of urine was infrequent and catheterisation was required in less than 2 per cent of patients. Attacks of lumbar and inguinal pain occurred in eight cases. They usually developed after the patient had begun to walk; the pain might be severe but was always transient. In three patients small burns were caused in the lower limbs by the plate of the diathermy circuit. In one case there was an increase in the lower limb weakness when the patient began to walk. This patient had well-marked osteoarthritis of the spine, and an extradural nerve was firmly adherent to the disc protrusion; weakness of dorsiflexion and eversion of the ankle was greater after operation. There have been three cases in which sudden weakness of dorsiflexion of the foot occurred several years after operation. In two it persisted for a few days only, but in the third it gave rise to a permanent foot drop necessitating a tendon transplantation. The explanation is not obvious. As the sudden onset of weakness was accompanied in each case by back and leg pains of a few hours' duration it is possible that a sudden displacement of more disc tissue caused the nerve injury.

RESULTS

We have already indicated that as the disturbance caused by disc protrusions is essentially subjective the assessment of the results of treatment presents difficulties. The first requisite is, we believe, a knowledge of the individual patient so that a fair comparison of his pre-operative symptoms and signs with his post-operative condition can be made. Secondly, the results of operation must be considered against a background of the indications which led to it. If pain of short duration and low intensity has been accepted as an indication for surgery it is clear that even mild post-operative symptoms denote part or complete failure. On the other hand, if operation has been reserved for patients whose pain has been severe or whose disability has been prolonged, mild post-operative symptoms may be much less important to patient and surgeon. In the present series operation has been confined to patients with severe or prolonged symptoms. Thirdly, to assess adequately the results of treatment a sufficiently large series of cases must be reviewed and they must be observed after operation

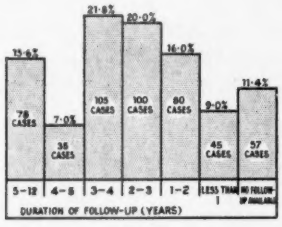

FIG. 22

Period of post-operative observation in the cases of the series.

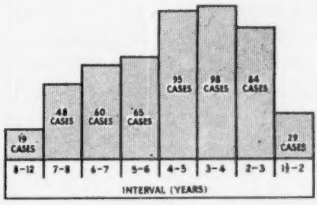

FIG. 23

Time interval since operation in the cases of the series.

for an adequate period. In this series 113 patients were observed for more than four years after operation; 218 patients were observed for more than three years; and 318 patients for more than two years (Figs. 22 and 23).

The results will be considered on the basis of: 1) freedom from lumbar and lower limb pain; 2) subjective disability; 3) capacity for work; and 4) objective findings.

Lumbar and lower limb pain. (*Table XIV*)—In 46·5 per cent of patients there were no symptoms referable to the disc lesion, while in 53·5 per cent some such symptoms were present. Lower limb pain was completely relieved in 77·6 per cent, but 22·5 per cent had some lower limb pain post-operatively. It was persistent in only eight cases (1·8 per cent); in the great majority it was slight and transient. Possibly scarring in and around the extradural nerve is at times responsible for this lower limb pain but there is also the possibility of small recurrent protrusions, insufficiently troublesome to warrant re-exploration. Low back pain was completely relieved in 60 per cent of the patients, but 40 per cent had some lumbar pain after operation. In only 6·2 per cent of these was this symptom severe or persistent. In most it was no more than a mild sense of discomfort after exertion.

Subjective disability—The patient's own opinion of the effectiveness of the operation is shown in Table XIV. The term *cured* implies complete absence of symptoms, apart from pre-menstrual backache or aching in the back or leg with climatic alterations. *Much improved* implies that the patient was well satisfied with the result but developed backache after heavy exertion or had had one or more transient attacks of acute back pain—sometimes spreading to the leg. If pre-operative muscular weakness was severe some may persist. It will be seen that over 92 per cent of the patients were either cured or much improved. *Improved* implies persistent or recurring pain in the back or leg, but reduced in severity and not such as to indicate re-operation in search of a recurrent protrusion. The three

patients unchanged by operation are later referred to as *incapacitated* and the probable reason for the poor result is indicated.

Capacity for work—On discharge from hospital our patients are advised as far as possible to avoid back strains. (Thus a girl contemplating a career in nursing is counselled against it.) Nevertheless one is usually reluctant to advise a complete change of occupation, with all the financial problems that this implies; caution and the avoidance of avoidable back strain is probably the only advice one can give to most patients. Many have returned to the heaviest

TABLE XIV

RESULTS OF OPERATION
(443 patients followed up)

	No. of cases	%
Symptoms		
No symptoms referable to disc lesion	206	46·5
Lower limb pain:		
absent	344	77·6
present { slight and transient 85 cases; severe and transient 6 cases; persistent 8 cases }	99	22·4
Lumbar pain:		
absent	266	60·0
present { slight on exertion 166 cases; severe on exertion 5 cases; persistent 6 cases }	177	40·0
Subjective result		
Cured	269	60·7
Much improved	140	31·6
Improved	21	4·7
Unchanged	3	0·7
Recurrence (proven)	10	2·3
Total	443	100
Capacity for work		
Full	411	92·8
Reduced	29	6·5
Incapacitated	3	0·7
Total	443	100
Physical signs		
Spinal signs	} Absent or greatly reduced in over 80% of cases	
Tension signs		
Neurological signs (378 cases examined)		
persistent motor disturbance { hypotonia and atrophy 32 cases; weakness 25 cases }	57	15·0
persistent sensory disturbance	114	30·0
persistent reflex disturbance	234	62·0

manual labour and others have been able to indulge in strenuous athletic pursuits such as rugby football and hockey. The results from the standpoint of work are shown in Table XIV. As would be expected most patients return to full work. Only three patients remained incapacitated: one because of severe osteoarthritis of the spine and the other two probably because of an overlying neurosis.

Objective findings. (*Table XIV*)—Of the *spinal signs* deformity disappears in most cases, except diminution in the lumbar curve, which frequently persists; local tenderness likewise disappears; movement of full range is usually restored though often it seems that full flexion is gained by a compensatory increased movement in the hips and upper lumbar joints—the

affected region of the spine remaining relatively immobile. The *tension signs* disappear in most patients: straight leg raising and femoral nerve stretching cause no more than a sense of tightness in the posterior muscles or the quadriceps. Persistent, though usually not significant, *neurological* disturbance is frequently seen. Reduction or absence of one or more of the tendon reflexes—in particular the ankle jerk—is the commonest abnormality and was seen in over 60 per cent of the cases. An area of reduced cutaneous sensibility was found in 30 per cent. Persistent disturbance of motor function was the least common neurological abnormality: *hypotonia* with *atrophy* was seen in 8·5 per cent. The disturbance was usually slight; except in the case of upper lumbar disc protrusions, when the quadriceps was involved, it affected the muscles innervated by the fifth lumbar and upper sacral roots—that is, the glutei, the hamstrings and the muscles below the knee. It is probable that a mild degree of atrophy in the peronei and dorsiflexor muscles of the ankles and toes will frequently pass unnoticed; so also will atrophy of the intrinsic muscles of the foot. Demonstrable *muscle weakness* was observed in 6·5 per cent of the cases followed up. This may affect any of the muscle groups mentioned above, but the groups most frequently affected were the dorsiflexors of the hallux or lateral toes and, less commonly, the plantar flexors of the toes. Muscles of relatively small mass at the periphery of the limb supplied by the affected anterior root or roots seem especially liable to suffer lasting weakness. Nevertheless the residual weakness was usually very slight. The five patients who developed a severe paraparesis in association with massive disc protrusion gained adequate motor recovery. The rate of recovery appeared to depend upon whether compression or trauma had been responsible for the cauda equina disturbance. In two of these patients severe weakness of dorsiflexion and eversion of one ankle have persisted, and it is noteworthy that there have been a few other patients in the series who complained primarily of an isolated weakness of the same movements. At operation in this latter group a large protrusion particularly related to one extradural nerve was found. Removal of the protrusion was not followed by recovery of motor function in several cases of this group.

The frequent persistence of impairment of tendon reflexes is perhaps explained by the fact that they depend upon the integrity of both motor and sensory fibres. Even when the loss of either type of fibre is insufficient to produce demonstrable motor or sensory disturbance their combined loss may cause reflex disturbance. Moreover the large fibres in the posterior nerve roots which subserve proprioceptive sensibility are the most vulnerable to compression. Reduced cutaneous sensibility is explained thus: an intervertebral disc protrusion injures the posterior nerve root fibres central to their ganglion cells; if this injury is severe enough to cause fibre degeneration, the consequent sensory deficit will be persistent because there is no regeneration of the parts of these root fibres within the spinal canal. It has been noted that paralysis of the dorsiflexors of the ankle and toes and of the evertors of the foot on one side may persist after the removal of a massive central protrusion which caused a cauda equina syndrome. It may also persist after the excision of a large laterally placed protrusion when its effects appeared to be largely confined to the extradural nerve. In each type of case there is almost certainly injury to both the intradural nerve roots and the extradural nerve at the level of the protrusion. Perhaps the tension within the extradural nerve renders it especially vulnerable, and the severe lesion produced in it may play an important part in the causation of the paralysis under discussion.

Recurrent protrusions—The reported frequency of recurrent intervertebral disc protrusions after operation varies among different authors. It must be remembered that only a proportion of patients with persistent or recurrent post-operative pain will be submitted to a second operation. The problem of assessing the severity of the symptoms exists here just as it did before the primary operation, and there will be a natural reluctance to submit the patient to multiple operations. In the present series recurrent symptoms of such severity as to indicate re-operation occurred in ten patients (2 per cent). All of them were cured by the second

operation, which usually revealed a recurrent protrusion in the same position as that previously excised. This was not so in three of the ten cases: in one patient a protrusion of the adjacent disc had occurred, and in another a protrusion of the same disc but on the opposite side; in the third patient adhesions only were found, binding the extradural nerve to the scarred posterior longitudinal ligament—division of the adhesions and a posterior rhizotomy relieving the symptoms.

CONCLUSIONS

1. Excision of a lumbar intervertebral disc protrusion is required in only a small proportion of patients with this lesion.

2. A careful clinical and radiological examination of cases of lumbago and pain in the lower limb provides good evidence not only of the presence of a lumbar intervertebral disc protrusion but also of its anatomical level, size and relationships. Such examination is essential for the selection of the patients requiring surgical treatment.

3. In most of these selected cases, a carefully performed operation designed to relieve the affected nerve fibres from forces which stretch and compress them will give satisfying relief of symptoms. In the series reported, 92 per cent of patients were either completely free from symptoms or very greatly improved after operation.

4. The spinal and tension signs present before operation largely disappeared after it. Persistence of a pre-operative neurological deficit after operation is, however, relatively frequent, though seldom disabling.

5. The incidence of post-operative recurrence of symptoms of such severity as to indicate re-operation in the series was 2 per cent.

I should like to record my indebtedness to all those who have helped me in this work, particularly to Mr Harold Wilson who gave me the opportunity of beginning the work when I was his chief assistant, and to Sir James Paterson Ross who later made its continuation possible. I am indebted to orthopaedic colleagues, Mr S. L. Higgs, Mr H. Jackson Burrows, Mr W. D. Coltart and Mr L. W. Plewes for many of the cases.

REFERENCES

MIXTER, W. J., and BARR, J. S. (1934): New England Journal of Medicine, **211**, 210.
O'CONNELL, J. E. A. (1943): British Journal of Surgery, **30**, 315.
O'CONNELL, J. E. A. (1944): Surgery, Gynecology and Obstetrics, **79**, 374.
O'CONNELL, J. E. A. (1946): British Medical Journal, **1**, 122.

THE CAUSES OF UNSATISFACTORY RESULTS FROM THE OPERATIVE TREATMENT OF LUMBAR DISC LESIONS

J. R. Armstrong, London, England

The exact place and value of operation in the treatment of lesions of the lower lumbar intervertebral discs is still the subject of much unprofitable controversy. It is clear and has been accepted that almost all patients recover partly or completely after conservative treatment alone. There has, however, been no general agreement about the exact indications for operative treatment, about the percentage of patients who require operation, or about the results which may be expected after surgical intervention; nor have these problems been much clarified in recent discussions.

This uncertainty concerning an important contribution to the treatment of a common and disabling condition is surprising. Removal of diseased lower lumbar discs has been practised for more than fifteen years—ample time to allow a critical appraisal of the procedure. Nevertheless it is probably true to say that most medical practitioners in this country regard the surgical treatment of a " prolapsed disc " as a rather speculative measure, only to be advised as a last and somewhat desperate resort. It is true that operation is not uniformly successful. In the recorded series anything between 5 and 40 per cent of unsatisfactory results have been reported, and every surgeon dealing with large numbers of these lesions meets with disappointments from time to time. In the present writer's view both too much and too little attention is paid to these unsuccessful operations: too much attention in the sense that the comparatively small percentage of poor results is used on argument that surgery is never indicated in this condition, without regard for the many patients who are completely relieved by operation after conservative treatment has failed; and too little attention in that not enough time has been spent in analysing the causes of failure. It may be, of course, that a certain proportion of disc lesions, especially in the late stages, are not amenable to surgery, and that in such cases poor results are inevitable. The writer does not believe this to be so.

This paper is based on the findings in patients with " failed " operation for disc lesions seen at various hospitals. The series included Service patients and civilians from all over the country; they had been operated on by many different surgeons. The writer considers that it is possible to determine the cause of failure in most instances, and that the causes may be classified.

THE PRINCIPLES UNDERLYING OPERATIVE TREATMENT

The aim of operative treatment is simple—the removal of all degenerated disc tissue, whether displaced or not. Afterwards, rest and splinting of the lumbar spine will allow firm fibrous healing of the disc remains. Provided there is the least possible damage to other structures, the actual details of operative technique are not of themselves important; but it is important that the causes of unsatisfactory results should be recognised clearly, and avoided by suitable modifications of technique.

CAUSES OF FAILURE

Wrong diagnosis is perhaps the most frequent cause of unsatisfactory results from operation. A patient with persistent low back pain may be subjected to laminectomy; no disc lesion is found—because none exists—and the patient will be no better, and may even be worse than before. The case is then quoted as unsatisfactory and serves only to obscure the issue whether the surgical treatment of disc lesions is or is not valuable.

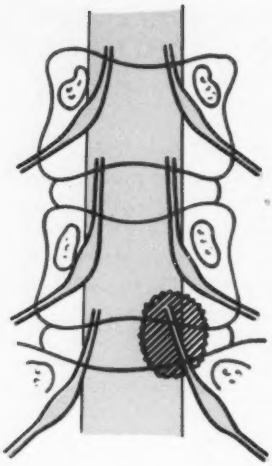

FIG. 1

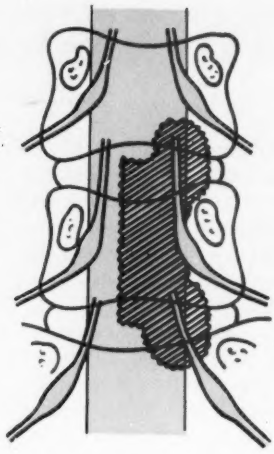

FIG. 2

Relative exposure obtained by the interlaminar approach (Fig. 1) and by the hemilaminectomy approach (Fig. 2). In each case the shaded area indicates the amount of bone and ligamentum flavum removed. Note the relationship between the theca, the spinal nerve roots and the lower two lumbar discs, and the much better access afforded by the hemilaminectomy approach.

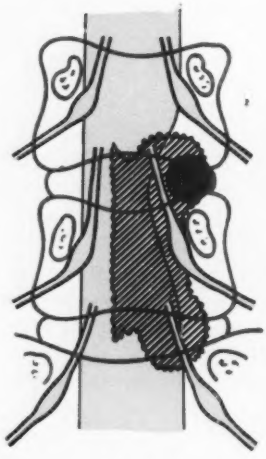

FIG. 3

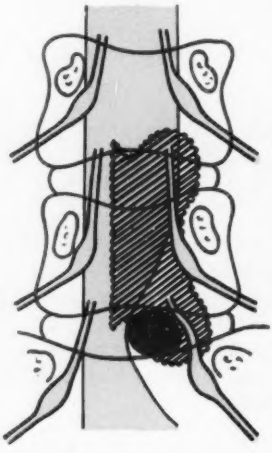

FIG. 4

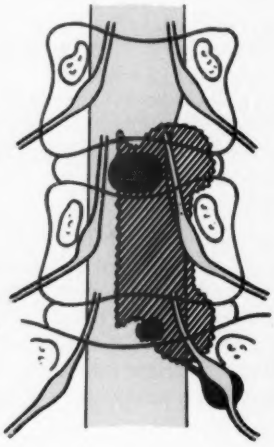

FIG. 5

The hemilaminectomy approach gives an adequate exposure of a pararadicular lesion (Fig. 3) or of a paracaudal lesion (Fig. 4) but a central lesion or a displaced nuclear sequestrum may be relatively inaccessible (Fig. 5).

In patients with genuine disc lesions who are not relieved by operation, the causes of failure may be classified in twelve ways:

1. *Failure to locate the lesion*—A lumbar intervertebral disc lesion may be present but may not be found at operation. This complication is under the direct control of the surgeon and usually occurs in one of three ways. *a*) Limited exposure may be carried out at the wrong level. The spinal canal may be opened by an interlaminar or " fenestration " approach at a level other than that at which the lesion exists—a limited approach which allows inspection of one disc only, the diseased disc never being seen by the surgeon (Figs. 1 and 2). *b*) The spine may be explored at the proper level, but, because of a poor exposure or haemorrhage from the extrathecal veins, the diseased disc may be obscured and either not found or not recognised. *c*) The exposure and recognition of the diseased disc may be a difficult technical problem and for this reason the lesion may be either not recognised or not adequately dealt with. The commonest types of lesion presenting especial problems are the central prolapse (Fig. 5), the " concealed " disc (that is, a degenerate disc which has not yet reached the stage of nuclear retropulsion), and the disc lesion associated with a displaced nuclear sequestrum (Fig. 5). All these lesions may be difficult to expose and recognise (especially so through an interlaminar exposure), and a nuclear sequestrum which has become widely displaced in the spinal canal may be quite inaccessible through such an approach (Figs. 3 to 5).

2. *Failure to recognise a double lesion*—In 12 to 20 per cent of all patients both the L.4–L.5 and the L.5–S.1 discs are affected simultaneously, and such a double lesion often cannot be recognised clinically. In these cases a bad result is inevitable if one disc only is exposed and dealt with. The only safe course is to expose and inspect both discs.

3. *Failure to deal with a bilateral lesion*—Many disc lesions are bilateral; that is, they either extend across the mid-line or else there are two separate retropulsions, one on each side of the mid-line. Such discs can be adequately dealt with only if they are exposed from both sides of the spinal cord; a unilateral exposure gives an unsatisfactory result.

The next three complications also are under the control of the surgeon and arise from the way he deals with the abnormal disc. They are:

4. *Subsequent further retropulsion of nuclear tissue*—It is not enough to remove the displaced nuclear tissue alone: the whole of the diseased nucleus must be removed. If it is not—if, as Burns and Young (1947) put it, " the charge is not removed from the shell "—more nuclear tissue may subsequently be displaced and cause a recurrence of symptoms.

5. *Root damage*—The nerve root in its extrathecal course is often adherent to the retropulsed nuclear material, particularly in lesions of long standing. The root may be damaged while it is being freed or by too vigorous retraction. The consequent sensory or motor disturbances may be permanent.

6. *Root adherence*—After operation the root always tends to adhere to the scar of the track through which the diseased nuclear material has been removed. This always happens and is unavoidable to some extent. The root is liable to adhere particularly to nuclear tissue or to tags of the annulus fibrosis or posterior longitudinal ligament. Root adherence after operation can therefore partly be prevented by complete removal of the nucleus and of all loose tags.

Two complications not under the direct control of the surgeon may cause unsatisfactory results. They are:

7. *Subsequent prolapse of previously healthy disc*—A disc that is healthy at operation may later become abnormal and cause the recurrence of symptoms. This, in the writer's opinion, is a very uncommon source of post-operative complications; in most alleged cases a double lesion has been missed at operation.

8. *Permanent changes in the nerve root*—If a nerve root is compressed or stretched by retropulsed nuclear material for too long, permanent and irreversible changes may occur in the root itself, and its function does not return after removal of the displaced nuclear tissue. This complication indicates that operation has been delayed too long.

Two complications which may be described as " articular " are partly under the control of the surgeon. They are:

9. *Damage to the posterior articular facets*—Damage to the posterior articular facets on one side is little regarded by some surgeons; indeed, routine decompression of the nerve root in the foramen is sometimes advocated. The writer holds the firm opinion that damage to the facets, even on one side, produces an irritable joint which is a source of post-operative symptoms and usually requires subsequent arthrodesis.

10. *Arthritis of the intervertebral joint*—Degeneration or removal of the nucleus pulposus disorganises one intervertebral joint (Figs. 6 and 7) and subsequent arthritic changes are inevitable. These changes take place in all three parts of the affected joint; that is, between

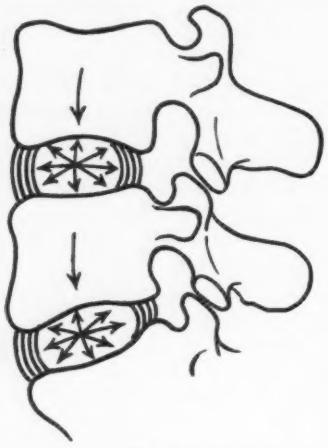

FIG. 6

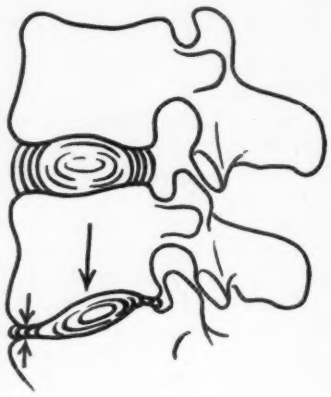

FIG. 7

Normally the nucleus pulposus distributes forces equally over the surface of the vertebral body and the annulus (Fig. 6). But when the nucleus has been destroyed or extruded, weight is no longer equally distributed, the vertebral bodies become approximated and there is disorganisation of the posterior intervertebral joints (Fig. 7).

the vertebral bodies and in the posterior articulations. But if post-operative treatment is adequate the damaged joint usually settles down into a state of symptomless fibrous ankylosis. If post-operative treatment is inadequate—particularly if any attempt is made to mobilise the damaged joint while it is still irritable—symptoms tend to persist and increase until further surgical measures become necessary. The writer believes that this complication can be controlled almost completely by an adequate post-operative regimen. It is surprising how often, between three and six weeks after operation, patients are subjected to a course of vigorous spinal exercises, and sometimes even to manipulation with the intention of " mobilising " the lumbar spine. The effects of such ill-judged attempts at " rehabilitation " are invariably most unsatisfactory.

In both this country and America it has been suggested that, because the removal of a damaged nucleus inevitably disorganises an intervertebral joint, immediate arthrodesis is desirable. Without discussing in detail the arguments for or against immediate arthrodesis, the writer is of the opinion that it is undesirable, except in a few very special cases, because: *a*) it is unnecessary for the vast majority of patients; *b*) the recorded results of operation with immediate arthrodesis are on the whole worse than those without arthrodesis; *c*) to perform an operation that is likely to produce an effective bony arthrodesis involves some increase in

the immediate operative difficulties and dangers and a very great increase in the period of post-operative incapacity; *d*) when necessary an arthrodesis can be carried out in a second stage; and *e*) re-exploration, should it become necessary, is greatly complicated by a previous arthrodesis.

The final two causes of operative failure will be mentioned only for the sake of completeness; elementary though they may seem, they are by no means unknown.

11. *Post-operative infection*—Infection may take the form of wound infection, meningitis, or sub-acute infection between the vertebral bodies themselves. Any infection is associated with widespread post-operative adhesions involving the theca and extrathecal nerve roots. An infection between the vertebral bodies causes an irritable lumbar spine requiring months of immobilisation.

12. *Gross damage to the spinal theca, to the cauda equina or to extrathecal nerve roots*—Gross damage to these structures may be done during the exposure or from careless retraction. Opening the theca at operation adds to the immediate difficulties and causes undesirable post-operative symptoms. The results of gross damage to the cauda equina itself may be catastrophic, and gross damage to an extrathecal root or roots may produce crippling after-effects.

The patient in whom an operation for a lumbar disc lesion has failed to produce relief always presents a very difficult problem. Far too often this problem is regarded as insoluble and is never squarely faced by the surgeon. Some surgeons consider a spinal fusion, when it has not been done already, as the only solution, and advocate and practise this measure in all such cases.

In the writer's view it is usually possible to determine the cause of unsatisfactory results. Many patients can be relieved by further treatment, the nature of which depends of course upon the condition that is present. Conservative treatment, re-exploration and spinal fusion all have their place and value, and their intelligent and specific application makes it possible to salvage many patients otherwise destined to some degree of chronic invalidism.

REFERENCES

BURNS, B. H., and YOUNG, R. H. (1947): Backache. Lancet, 6454, 623.

PSEUDARTHROSIS OF THE TIBIA IN CHILDHOOD*

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The purpose of this paper is to report the late results of treatment by the use of the " by-pass " graft, to give a brief account of all the patients treated, and to discuss the possible causes of inception and maintenance of the condition.

It is now fourteen years since the by-pass graft was first introduced. It was used for two patients in the same year and both cases were described in my original paper in 1940. As far as can be ascertained these were the first recorded successes in the treatment of pseudarthrosis of the tibia in childhood. In that paper also is reported the successful use of a double onlay graft (later described by Boyd, 1941) but this has been discarded in favour of the by-pass operation because the latter was more certain in its effect. In all cases the graft has been taken from the sound leg and has been taken from as far up the tibia as practicable in order to obtain a graft with the highest possible proportion of cancellous to cortical bone. Although obviously the cortex is essential for success, previous experience had shown that bone grafts for ordinary non-union became incorporated more quickly and with greater

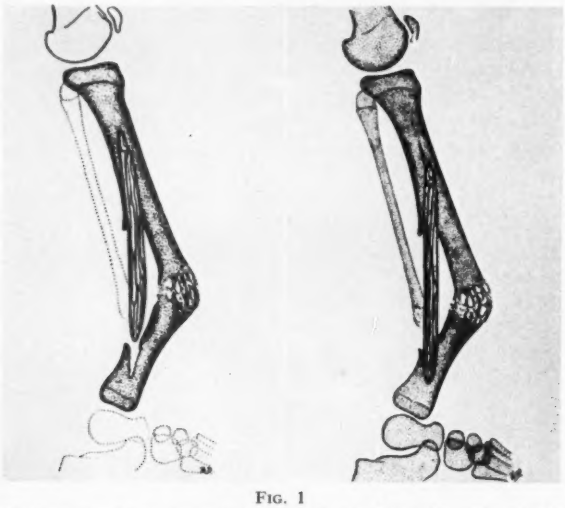

FIG. 1

The by-pass graft for congenital pseudarthrosis of the tibia. The method of insertion is similar in principle to that of the bolt-graft used in ordinary inlay grafting.

certainty if taken from the part of the tibia where the cortex is thin and cancellous bone preponderates. The method of insertion described in the original paper has been employed in each operation (Fig. 1). It is similar in principle to the " bolt-graft " used by the author since 1929 for all grafting operations on the long bones. Interestingly enough Rizzo and Lehmann reported its use in 1947, having apparently thought of it quite independently. It has the great advantage of not requiring any foreign material to hold it in place, and also of

* Paper read at the spring meeting of the British Orthopaedic Association, 1950.

imparting immediate stability to the limb. That is to say stability sufficient for easy handling though not of course for bearing weight.

RESULTS

The first patient, N. K., operated upon in 1936 at the age of eight years, is now twenty-two years of age: he is married and works as a clerk in a timber merchant's office. The condition of the leg before the by-pass grafting operation, eighteen months after operation, and fourteen years after operation is shown in Figures 2 to 6. Before the insertion of the by-pass many attempts had been made to secure union of his tibia. The limb is now two and three-quarter inches short. This is about the same as in 1939. The bowing then present has largely disappeared although nothing has been done to correct it. Correction has occurred naturally as it has in the other cases.

The second patient, W. P., operated upon at the age of three and a half years, is now nineteen years of age. Figure 7 shows the condition before operation. Radiographs of the leg six months after operation, and fourteen years after operation are shown in Figures 8 and 9. The limb is three-quarters of an inch short, just as it was in 1939.

During the last fourteen years seven further patients with this type of pseudarthrosis have been treated, making nine in all. This is not a large series and although allowance must be made for the interruption of war it is clear that the condition is not a very common one. To my own series are now added two patients treated successfully by other surgeons. Mr Pulvertaft's case (Fig. 10) illustrates the use of the by-pass when the bowing is posterior. Although the employment of screw fixation is not part of my own technique, no harm has resulted. I do not favour screws because I have seen instances of fracture across the bone in the plane of a screw hole some time after resolution of the original lesion. Mr Birkett's patient (Figs. 11 to 20) is extensively illustrated because the radiographic record he has preserved is so delightfully instructive.

Of my own nine patients, sustained success has been achieved in seven. The two failures occurred last year during the first three post-operative months. Although it is generally felt in orthopaedic circles that results ought not to be assessed in less than three to five years, one may presumably claim a failure more quickly than a success. And in any case, however long one were to wait, these two attempts would have been initially unsuccessful. In neither patient was the principle or technique of the operation at fault. Rather was the surgeon's judgment to blame in the way he dealt with the somewhat unusual features. The first patient, P. J. (Figs. 21 to 23), was operated upon at the age of eleven months. Stored rib was used for the graft and was found to be very suitable. Although the post-operative plaster included the flexed knee, the child, who was distinctly chubby, worked the plaster down the leg and cracked the graft across the " popliteal angle " of the plaster (Fig. 22). This uncooperative tendency was overcome by leaving the sole of the foot free of plaster, but neither the graft nor the tibia united (Fig. 23). Although there should be no difficulty in holding such a leg in plaster (we do so for hundreds of children with congenital club foot) it seems that in a similar case it would be well to defer operation until the age of about eighteen months when the child might reasonably be expected to be more manageable. Moreover the recipient bone would then be larger and the operation would be technically simpler. The second failure was in a child of three years who had received no previous treatment (Figs. 24 and 25). A large part of the tibia above the pseudarthrosis was defective, and although the graft was as long as could be obtained from the sound tibia it was not long enough adequately to clear the area of bone absorption. Consequently its lower end shared the fate of any other graft placed in that area and disappeared. It is unlikely that a double onlay graft could have been clamped to such an attenuated bone as was present above the lesion, but the surgeon might reasonably have risked placing the by-pass lower down. A second by-pass graft has since been undertaken in this child and union has now occurred.

FIG. 2

FIG. 3

Case 1. Figure 2—Appearance of the limb at the age of eight years.
Figure 3—Radiograph at the age of eight years.

FIG. 4

FIG. 5

FIG. 6

Case 1. Figure 4—Condition eighteen months after by-pass grafting. Figure 5—Fourteen years after grafting. Figure 6—Present condition at the age of twenty-two years.

FIG. 7

FIG. 8

FIG. 9

Case 2. Figure 7—Condition of leg before operation, at the age of three and a half years. Figure 8—Six months after operation. Figure 9—Fourteen years after operation.

FIG. 10

Case 3—A successfully treated case in which the upper end of the graft was fixed by screws. (Reproduced by courtesy of Mr R. G. Pulvertaft.)

FIG. 11

FIG. 12

Case 4. Figure 11—Child aged one year. Marked anterior bowing but no fracture. Figure 12—Condition at the age of five years. (These and the nine succeeding illustrations are reproduced by courtesy of Mr N. Birkett.

FIG. 13

FIG. 14

FIG. 15

Case 4. Figure 13—Aged six years. Inlay grafting has been unsuccessful. Figure 14—Six months later the graft has been almost completely absorbed. Figure 15—Aged nine years. Massive double onlay graft.

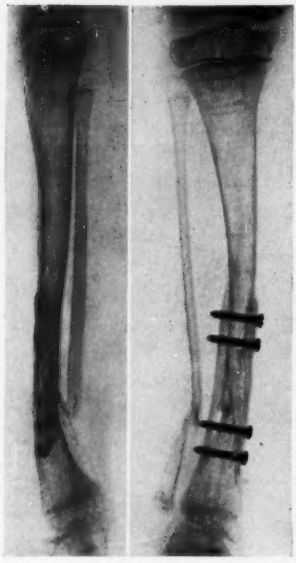

FIG. 16

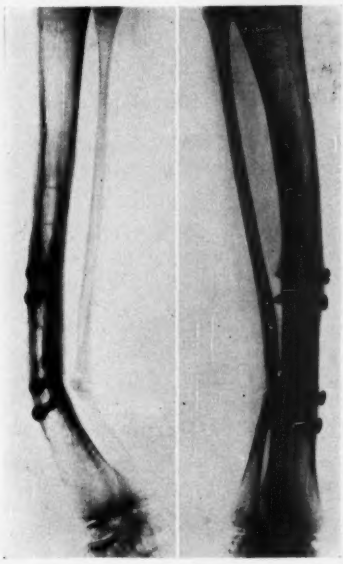

FIG. 17

Case 4. Figure 16—Four months later, union appears satisfactory. Figure 17—Three years after double onlay graft. Union appears consolidated.

FIG. 18

FIG. 19

FIG. 20

Case 4. Figure 18—Three and three-quarter years after double onlay graft. Absorption of bone around the lowermost screw. Figure 19—Three months later, recurrent pseudarthrosis. Figure 20—Age fourteen years. Seven months after by-pass graft. The graft is incorporated at its upper and lower ends. Hypertrophy of bone is taking place along the line of the graft.

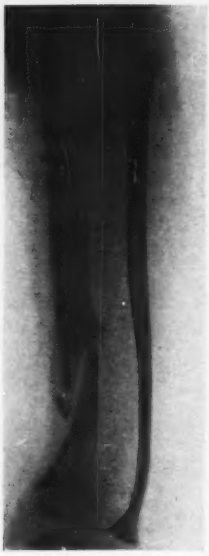

FIG. 21

FIG. 22

FIG. 23

Case 5. Figure 21—Condition at age of eleven months, immediately before operation. Figure 22—Two months after operation, showing break in graft caused by the child working the plaster off the leg. Figure 23—Ten months after operation. The lower end of the graft has been absorbed.

FIG. 24

FIG. 25

Case 6. Figure 24—Condition at the age of three years. Note the extensive area of tibia affected. Figure 25—Four months after operation. Failure of lower end of graft.

FIG. 26

FIG. 27

Case 7. Figure 26—Radiograph showing by-pass operation after failure of inlay graft. The strut consisted partly of the original inlay graft and partly of tibial bone to which it was fused. Figure 27 shows sound bone union six months later.

One of the successful cases is of special interest. A boy aged twelve years had previously been treated elsewhere, first by an inlay graft and later by a by-pass. His parents were unwilling for another piece of bone to be taken from his sound tibia. The affected leg was opened with the intention of packing iliac chips into the angle at the lower end of the graft, which had been placed too high and too medially. But on inspection at operation this was thought to have a poor chance of success. The existing graft therefore was first removed together with a three-inch length of tibia to which its upper end was fused; and the composite bone—part graft, part tibia—was reversed so that the upper end became the lower and was implanted in the usual way. Sound union ensued (Figs. 26 and 27).

PATHOGENESIS

In dealing with these patients the question naturally arose as to why the pseudarthrosis develops, and why it persists in spite of all efforts which would ordinarily produce union. Complete and prolonged immobilisation has failed, step grafts and inlay grafts have failed, and even sliding grafts of half tibial thickness have failed. At one time (about 1932) the author had the impression that in the lesion there were cells possessing a destructive quality equivalent to that present in conditions of local malignancy such as, for example, osteoclastoma. But the evidence is against this for three reasons: 1) In one case the whole area of the pseudarthrosis was excised together with two inches of tibia above and below the lesion: length was maintained by traction for some weeks and the gap was subsequently bridged by an implanted section of fibula: this shared the same fate as any other graft. 2) No destructive cells have been seen in the many sections that have been taken. 3) When fixation is adequate the destructive process is arrested and the bone re-forms. The cause of persistence of the pseudarthrosis must therefore be mechanical. The author's present view is that angulation

and fracture are coincident, and that the bending stress continually maintained by the muscles stimulates bone resorption to a greater degree than the body can tolerate. Under the bending stress the woven bone with which the body attempts to heal the fracture breaks down as quickly as it is formed. This struggle between repair and destruction gives rise to the typical appearance of these fractures.

Many hypotheses have been put forward to explain the initial cause of this peculiar pseudarthrosis. That it is not a " birth " fracture is abundantly clear. If a fracture of a normal tibia at birth occurs at all it does so very seldom indeed. Not only is such a fracture not included among the large number of birth fractures the writer has treated; it is also absent from the list of birth defects recorded in two maternity hospitals whose combined total of births in the last ten years was 48,000. Moreover the author has knowledge of only one case in which pseudarthrosis was encountered within a short time after birth. This was in a patient seen by Mr Goronwy Thomas of Liverpool (Fig. 28). The radiograph shows that the tibia was not normal before it broke: part of the shaft was thin and dense. Reference will be made later to this typical defect.

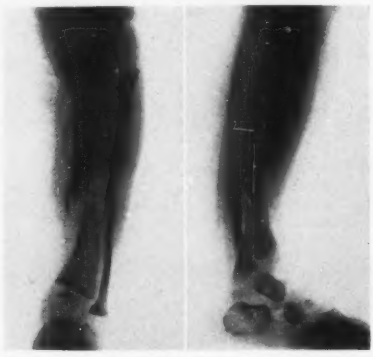

FIG. 28

Radiograph showing tibia fractured soon after birth. Pseudarthrosis developed but it is clear that the tibia was defective before it broke. (Reproduced by courtesy of Mr G. E. Thomas.)

FIG. 29

Wedge defect of tibia, suggesting the possibility of development from multiple ossific centres. Pseudarthrosis did not develop.

The possibility of a separate centre of ossification was suggested by the case illustrated in Figure 29, but this child did not develop pseudarthrosis and no evidence of multiple ossific centres has been present in the established cases.

An attractive theory is postulated that in utero a foot in extreme calcaneus would press on the tibia and render it defective in such a way that it would subsequently break very readily. This theory would also explain the laxity of the calf muscles and the consequent tendency to calcaneus which is such a constant feature of the clinical picture of pseudarthrosis. But children born with calcaneus deformity do not develop pseudarthrosis: the tibia is often normal and even if it is bowed posteriorly it does not break and then fail to unite. Even if a tibia with congenital posterior bowing is corrected by osteotomy it unites quite readily (Fig. 30).

The explanation most satisfying to the author is that a fatigue fracture occurs in a congenitally defective tibia. The fracture occurs usually within about the first year of walking. There is no doubt that in all cases of pseudarthrosis a defect exists in the shaft of the tibia in addition to the fracture itself. The defective area varies in length but may involve nearly

FIG. 30

FIG. 31

FIG. 32

Figure 30—Uneventful union of the tibia and fibula after corrective osteotomy for congenital posterior bowing.

Figure 31—Cystic changes in shaft of tibia. Figure 32—Same case three months after by-pass operation.

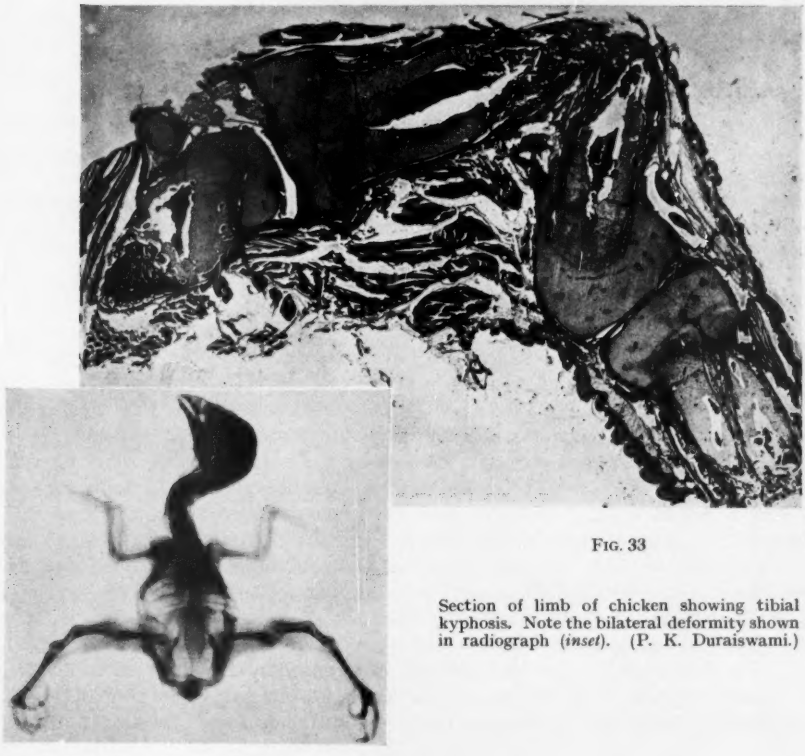

FIG. 33

Section of limb of chicken showing tibial kyphosis. Note the bilateral deformity shown in radiograph (*inset*). (P. K. Duraiswami.)

the whole shaft. Usually the bone is attenuated and dense but occasionally it is cystic (Figs. 31 and 32). This hypothesis does not rest entirely on clinical evidence. Duraiswami (1950), working in the Department of Orthopaedic Surgery of the University of Liverpool, has, by injecting insulin into the yolks of hens' eggs, caused various congenital defects in the chickens. By appropriate dosage and timing of the injection he has been able to determine the defect which will be present at birth. Figure 33 shows one of the chickens in which defects in the tibia closely resembling the pseudarthrosis in children were produced. It is not unreasonable to suppose that some influence may similarly affect the human embryo and give rise to a similar dysplasia of the mesenchyme which later results in a defect of the tibia.

SUMMARY

1. The results of the by-pass grafting operation in eleven cases of pseudarthrosis of the tibia in childhood are presented.
2. The operation was successful in securing sound bone union in nine cases, and unsuccessful in two.
3. The causes of failure in the two unsuccessful cases are analysed.
4. The possible causes of occurrence and persistence of tibial pseudarthrosis in childhood are discussed.
5. It is suggested that the pseudarthrosis results from a fatigue fracture of a congenitally abnormal tibia, but that its persistence depends entirely on mechanical factors.
6. There is evidence to suggest that the underlying congenital abnormality may arise from dysplasia of the mesenchyme.

REFERENCES

BOYD, H. B. (1941): Journal of Bone and Joint Surgery, **23,** 497.
BOYD, H. B. (1943): The Treatment of Difficult and Unusual Non-unions with special reference to the bridging of defects. Journal of Bone and Joint Surgery, **25,** 535.
BOYD, H. B., and FOX, K. W. (1948): Congenital Pseudarthrosis, follow-up study after massive bone grafting. Journal of Bone and Joint Surgery, **30–A,** 274.
DURAISWAMI, P. K. (1950): Insulin-induced skeletal abnormalities in developing chickens. British Medical Journal, **2,** 384.
McFARLAND, B. (1940): British Journal of Surgery, **27,** 706.
RIZZO, P.-C., and LEHMANN, O. (1947): Journal of Bone and Joint Surgery, **29,** 354.

NOTE ON PSEUDARTHROSIS OF THE TIBIA IN CHILDHOOD

A Discussion Arising from the Preceding Paper, with some General Observations on the Healing of Fractures

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It is with some diffidence that I add observations to the subject that McFarland has made his own, but my genuine excuse is related to the hours of thought and work that have been provoked by the case he has kindly included in his series (Case 4, page 40). After the case had been discussed with him, a further event took place. Although firm union had been secured, the girl refractured her leg at the junction of the graft and lower third of the tibia, and despite immobilisation it proceeded towards non-union (Fig. 1). It seems possible that persistence of the pseudarthrosis might have arisen from factors that have not previously been discussed fully. Why, in this case, did the double onlay graft take satisfactorily but later fracture; and why did the by-pass graft then succeed and later fracture at the lower junction with the host? The grafts took satisfactorily and appeared to be well-nourished. It can be admitted that in the first operation of double onlay graft the screw holes formed a good reason for local weakness; but after there had been fracture through the site of insertion of one screw, why was there no attempt at union?

The underlying principles seem clear to me now and if, after further experience, they are accepted as valid by others, they support McFarland's contention that the by-pass graft offers the greatest hope of success in the treatment of these difficult cases.

Teaching of the anatomy of the limbs gives a fair idea of muscle function in relation to the origin and insertion of muscles and their tendons, and of their action in relation to joints. At first sight, the shape of a limb appears to be determined by the shape of bones and joints, and the muscles covering them; but scant attention has been drawn to the function of the deep fascia and intermuscular septa, except in relation to their special development to serve as pulleys in the neighbourhood of joints. Anatomical dissection shows that the deep fascia of the calf is well developed and has a considerable component of transverse fibres encircling the limb, and it seems clear that the deep fascia and intermuscular septa attached to it serve a definite function in preserving the shape of the limb and controlling the direction of muscular action.

When a deformity such as that shown in Figure 1 has existed for a long period, or has become established in infancy before the shape of the limb has become fixed, bow-stringing of the muscles must take place because the deep fascia is not developed sufficiently to maintain close apposition of the muscles to the bone. Muscle action then produces leverage at the site of fracture which results in a state of affairs that is incompatible with the development of bone—which fortunately is uncommon in adult fractures.

In the case under discussion deformity was long established; and at operation there was found, behind the tibia between the muscles and the bone, a space occupied by a fibro-fatty pad. At the first operation, after dissection and freeing the bone ends, and reducing them in length by stepping so that the tibia could be straightened without difficulty, an onlay graft was applied as a sandwich and the grafts were fixed by screws to maintain a straight and strong but rather shortened tibia. After operation the limb was protected in plaster for a long period. Union took place readily; the grafts and host bone lost their separate characters; and a living tibia reappeared. When the graft was incorporated, relaxation of external splintage was allowed but it was not long before refracture took place and the original deformity recurred.

This rapid return of deformity was quite unlike that which occurs after ordinary fractures of the middle or lower third of the tibia, and the reason for it was undoubtedly that there was no binding deep fascia to hold the muscle planes close to the tibia. Soon after the bone refractured bow-stringing again took place: a hinge action was set up at the site of fracture and non-union was inevitable.

The by-pass graft was carried out as the only reasonable alternative to repetition of the onlay graft and it is clear from the illustrations that, in some ways, it overcame the disadvantages arising from correction of the original deformity. The fascial attachments to the tibia in its deformed state were not interfered with, and the bone graft was inserted in a

FIG. 1

FIG. 2

Figure 1—Refracture at the junction of graft with lower fragment after by-pass grafting for pseudarthrosis of the tibia (same patient as in Case 4, page 40). Figure 2—Diagram to show lines of force in a limb with marked angular deformity. Arrows indicate lines of pull of various muscle groups. Distortion gives rise to bow-stringing of the posterior muscles, and stability can be reached only when a new shaft is formed on the axis of pull of the muscles. Compression forces along the graft are the sum of the components of muscle pull and weight-bearing. In this case the insertion of the graft into the lower fragment was too high and allowed further angulation to take place at the host-graft junction.

plane parallel to the line of muscular action. Its position ensured that it was subjected to longitudinal compression, and close apposition of muscles to the graft was maintained, for the graft lay behind the tibia where the fibro-fatty pad filled the angle between the bone fragments. After insertion of the graft the deep fascia and intermuscular septa were held forwards in the manner of guy ropes, to the deformed tibial shaft. The fascia remained taut; its original function was restored; and it took again its normal part in moulding the shape of the limb. It is clear that if a by-pass graft is to be effective the stress to which it is subjected at each end must be a direct compression force by which to stimulate union. The refracture seen in Figure 1 occurred because the graft was too short and was set too high in the lower

end of the tibia, so that an angle was formed which was broken by bow-stringing from muscular action. The next stage in repairing the bone must be to lay another bone graft posteriorly, deep to the calf muscles.

Surely, encompassed within the problems that this case presents, must lie the whole key to the persistence of living bone in the human body. It is now realised that living, functioning bone is not a static structure; its texture is always being modified by the process of bone formation and bone removal, and such activity is probably greatest in the natural compression lines of the body where stresses stimulate development of the internal architecture. It may well be that variation in the mechanical stresses imposed on bone is the cause of the continuous modifications that take place, just as it appears to be the cause of modification of bone where strength is impaired—as, for example, in active rickets or Paget's disease where buttressing on the concave side attempts to balance increasing angular deformity. If this is so, the texture of a long bone such as the tibia will probably persist intact only if its general contour is in line with the compression forces imposed upon it by surrounding muscles and weight-bearing. Figure 2 indicates the angle of pull of various muscle groups, the components of which must result, if the shape of the tibia is to remain constant, as a compression strain along the tibial graft and not as a strain exposing the graft to angulation. It is clear from the above discussion that compression stresses are necessary to ensure the integrity of healthy bones and to promote repair after fracture.

Other important factors that can complicate the transition of a fracture-haematoma to the cellular pattern of callus are the surface phenomena that exist between bone, fracture-haematoma and surrounding soft tissues. Bone in contact with other tissues in comparatively short time becomes surfaced by a compact layer within which sheath cancellous bone can achieve maturity from callus. Poor apposition of fragments, inefficient immobilisation and a poorly developed fracture-haematoma, seem to be the causes which allow the development of a similar surface phenomenon between the fragments and lead to non-union. This surface phenomenon is clearly revealed in fractures with angulation, where bone formation can be seen to be deficient on the convex side so that a permanent gap in the surface may result. Periosteum itself appears to have little power to form bone, but all bone surfaces and the surfaces of bone grafts appear to develop a periosteum. The healing of a fracture by bone graft appears to involve quite different principles from the union of a fracture by callus, and it seems likely that the main function of a bone graft, whether compact or cancellous, is to prevent a surface reaction arising between bone and soft tissue that can isolate the two fragments of the bone. The bone fragments and bone graft develop one sheath of compact bone, surfaced by periosteum, within which mechanical strains and stresses can develop the internal architecture.

If these considerations are correct then they help to account for early union of a difficult fracture following a large cancellous bone graft. The packed cancellous bone graft by its mass and its close fit to freshened bony surfaces promotes a surface reaction to the surrounding soft tissues which causes the laying down of a compact layer of bone. Within this the remoulding forces allow the development of living cancellous bone architecture without the development of callus in a fracture-haematoma, the process being comparable to the normal process of absorption and formation of bone constantly occurring in normal bone.

CONGENITAL POSTERIOR BOWING OF THE TIBIA WITH TALIPES CALCANEO-VALGUS

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The purpose of this paper is to distinguish three types of congenital bowing of the tibia and to support the view of Heyman and Herndon (1949) that posterior bowing, although comparatively rare, is nevertheless a clinical entity. These observers clearly described the condition and rated its prognosis as more favourable than that of the two types previously described in the literature. A review of this literature is interesting. In 1925 Ollerenshaw, writing on "Congenital Defects of the Long Bones of the Lower Limb," made a casual reference to forward bending of the tibia as an occasional finding. In 1934 Middleton described anterior bowing of the middle and distal thirds of the diaphysis, the presence of an extreme and fixed talipes equinus, the shortness and thinness of the lower limb as a whole, the puckered depression in the skin over the salient angle of the tibial deformity and the frequent presence of other developmental anomalies. He differentiated this type of congenital bowing from the one associated with pseudarthrosis occurring usually at the same site. Freund (1936) described a number of cases similar to Middleton's, and stressed the association of other congenital defects, particularly absence or deficiency of the fibula. In 1943 Williams clearly differentiated two types of congenital anterior bowing, in an article entitled "Two Congenital Deformities of the Tibia, Congenital Angulation and Congenital Pseudarthrosis." He pointed out that in cases of so-called congenital pseudarthrosis the tibia may be intact at birth and that in these cases there is no talipes equinus and there are no associated developmental faults. Boyd in 1941 wrote: "The prevalence of pseudarthrosis following osteotomy in cases of congenital bowing of the tibia and the extreme difficulty of securing union following such a pseudarthrosis suggest that the etiology in congenital pseudarthrosis and congenital bowing of the tibia may be related."

FIG. 1

Congenital anterior bowing of the tibia; fracture and established pseudarthrosis have occurred.

It seems advisable, in order to avoid ambiguity, to recognise the two types of anterior bowing and not to use the term congenital pseudarthrosis to cover both of them. When there is no associated foot deformity or other congenital anomaly, tibial bowing is almost invariably the precursor of pseudarthrosis (Fig. 1). For instance, in Camurati's (1930) series of twenty-seven cases of pseudarthrosis of the tibia, only four were shown with the tibia still intact, and in all four the bowing was anterior. Similarly in Wade's (1928) series of ten cases of congenital pseudarthrosis there were four in which the tibia, though initially

intact, was bowed forwards before the seemingly inevitable fracture and pseudarthrosis developed.

It has become clear that besides the two types of congenital tibial bowing already mentioned there is also a third, less common, type, in which the convexity of the bowing is posterior and medial and there is an accompanying talipes calcaneo-valgus so pronounced that the foot seems to nestle in the concavity of the tibia. From time to time isolated cases of this condition have been presented. Denis Browne published a photograph of one case in 1936, and Freund showed radiographs of another in 1936; Bordeu described the condition in 1943, and in April 1949 Dawson published a typical case under the title of " Intra-uterine Fracture of the Tibia and Fibula." Lastly, in July 1949, Heyman and Herndon published their observations. These are confirmed by my own experience, which is illustrated in the following five case records.

CASE REPORTS

Case 1—K. L., a girl, aged five months, seen at the Orthopaedic Hospital, Stoke on Trent. Marked posterior bowing of the right tibia with accompanying severe talipes calcaneo-valgus had been observed at birth, but no treatment given. Radiographs confirmed posterior and medial bowing at the junction of the middle and lower thirds of the right tibia and fibula (Fig. 2). The calcaneo-valgus deformity responded quickly to manipulation and splinting; the bowing of the leg was treated by repeated moulding and fixation in plaster (Fig. 3). At the end of twelve months the posterior bowing was well corrected but there was still some medial bowing, and half an inch of real shortening was observed. Splinting was continued at night only, and normal activities were allowed in the day-time. During later observation there was delayed growth in the right leg, although the epiphyses appeared normal. When the child was twelve years old the right foot was smaller than the left and showed slight cavus deformity; there was three-quarters of an inch of real shortening of the right leg, with one-quarter of an inch of wasting of the right thigh, and one inch of wasting of the right calf (Fig. 4); many small café-au-lait spots were also found, mostly on the left forearm.

FIG. 2

Case 1—Condition when the child was first seen, at the age of four and a half months. Note the posterior and medial bowing. Calcaneus deformity is obvious although the foot is being forcibly plantar-flexed.

FIG. 3

Case 1—Condition after five and a half months' treatment. The posterior bowing is less apparent, but the medial element is still prominent.

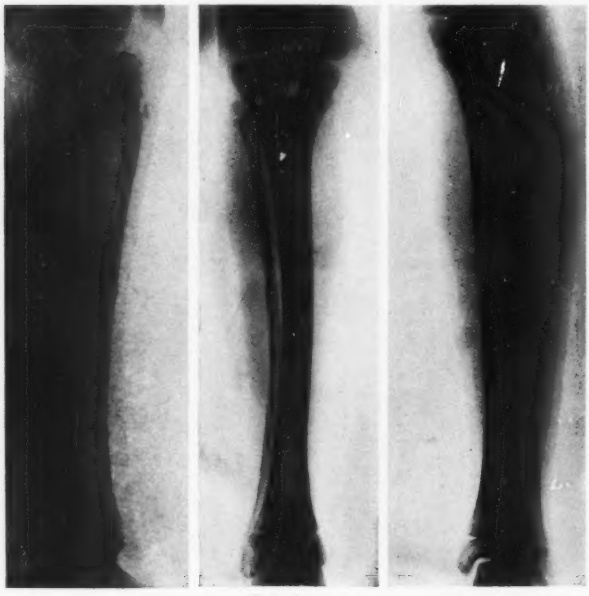

FIG. 4

Case 1—Radiographs at twelve years. Posterior and medial bowing of the right leg have almost disappeared, but growth has been deficient. Normal left leg is shown for comparison.

FIG. 5
Case 2—The bowing of the fibula conforms to the bowing of the tibia.

Case 2—S. I., a girl, aged sixteen days, with posterior and medial bowing of the right tibia and fibula and marked talipes calcaneo-valgus. Treatment was the same as for Case 1. Seven months later the position of the foot was good, and bowing of the leg was responding well to treatment (Fig. 5). At five years, four months, the child walked well with no instability or obvious deformity, but the leg was short.

Case 3—G. F., a boy, aged five weeks, with backward bowing of the lower third of the left leg. Calcaneo-valgus was marked, and the foot fitted neatly into the depresson caused by bowing. The skin was dimpled over the site of maximum convexity. There was no pseudarthrosis and no congenital anomaly. Treatment was manipulative moulding and retention in plaster. Seven months later he was much improved, but there was still some posterior bowing (Fig. 6).

FIG. 6
Case 3—After five months' treatment. Posterior bowing has improved, but the leg is obviously short.

FIG. 7

Case 4—At four months the bowing of the tibia is still pronounced, but the talipes calcaneo-valgus is well corrected.

Case 4—M. T., a girl, newly born, an apparently white child of a coloured mother. The right lower leg presented postero-medial bowing; the foot, in a position of pronounced calcaneo-valgus, lay in the concavity. After four months' treatment, bowing was still present but the right leg was half an inch short (Fig. 7). At the age of two years and ten months there was still some obvious bowing, the shortening had remained the same, and there was a slight limp.

Case 5—D. E., a girl, aged three weeks when first seen by Mr Roaf in Liverpool. There was marked calcaneus deformity of the foot and posterior angulation of the lower third of the leg. Radiographs confirmed the clinical findings and showed " buttressing " of the concavity of

FIG. 8

FIG. 9

Case 5—Figure 8 is a radiograph at three weeks. The buttressing of the concavity of the tibia is obvious and in its lower part gives the appearance of a fracture. In Figure 9, taken eighteen months later, the calcaneus deformity is seen to be well corrected; the angulation of the tibia is still present, but greatly improved. At the right the normal leg is shown for comparison: note the difference in lengths.

the tibial curve (Fig. 8). Initial treatment was manipulative moulding of the foot and retention in anterior plaster shell. Mr Roaf has reported the calcaneus deformity to be well corrected within three months, and bowing of the tibia to be greatly improved but still present when the child was last examined at the age of eighteen months (Fig. 9). There was just over half an inch of shortening.

DISCUSSION

These five cases support the view of Heyman and Herndon (1949) that congenital posterior angulation of the tibia, associated with talipes calcaneo-valgus, must be considered as a distinct clinical entity. In all the cases the calcaneo-valgus deformity was fully corrected without difficulty. The posterior angulation has also responded well to gentle moulding and fixation in plaster at monthly intervals. The medial bowing, on the contrary, has been more resistant to correction. All five cases showed a moderate impairment of growth in the affected leg. We have no evidence to indicate the natural course of the deformity if left uncorrected; nor do we know with certainty what would be the probable outcome after fracture or after osteotomy for correction of the deformity. But the analogy to anterior bowing, with its tendency to pseudarthrosis, is sufficient to demand a cautious attitude to surgical treatment.

SUMMARY

1. The literature dealing with congenital bowing of the tibia has been reviewed, and three types of deformity have been distinguished.
2. Five examples of the third type, in which the bowing is posterior and medial, are presented.
3. The characteristic features of the clinical entity are described, and the satisfactory response to conservative treatment is illustrated.

I am indebted to Mr Denys Wainwright of Stoke on Trent, to Mr R. Roaf of Liverpool, and to Dr J. C. Acker of Halifax, Canada, for permission to quote their cases.

REFERENCES

BORDEU, DIAZ E. (1943): Tibia Curva Congenita. Archivos del Hospital de niños Roberto del Rio, **11,** 232.
BOYD, H. B. (1941): Congenital Pseudarthrosis. Journal of Bone and Joint Surgery, **23,** 497.
BROWNE, D. (1936): Congenital Deformities of Mechanical Origin. Proceedings of the Royal Society of Medicine, **29,** 1409. (Section for the Study of Disease in Children.)
CAMURATI, M. (1930): Le pseudoartrosi congenite della tibia. Chirurgia degli Organi di Movimento, **15,** 1.
DAWSON, G. R. (1949): Intra-uterine Fracture of the Tibia and Fibula. Journal of Bone and Joint Surgery, **31-A,** 406.
FREUND, E. (1936): Congenital Defects of Femur, Fibula and Tibia. Archives of Surgery, **33,** 349.
HEYMAN, C. H., and HERNDON, C. H. (1949): Congenital Posterior Angulation of the Tibia. Journal of Bone and Joint Surgery, **31-A,** 571.
MCFARLAND, B. (1940): " Birth Fracture " of the Tibia. British Journal of Surgery, **27,** 706.
MIDDLETON, D. S. (1934): Studies on Prenatal Lesions of Striated Muscle as a Cause of Congenital Deformity. Edinburgh Medical Journal, **N.S. 41,** 401.
MIDDLETON, D. S. (1934): The Pathology of Congenital Genu Recurvatum. British Journal of Surgery, **22,** 696.
OLLERENSHAW, R. (1925): Congenital Defects of the Long Bones of the Lower Limb. Journal of Bone and Joint Surgery, **7,** 528.
WADE, R. B. (1928): The So-called Congenital Pseudarthrosis of the Tibia. Journal of the College of Surgeons of Australasia, **1,** 181.
WILLIAMS, E. R. (1943): Two Congenital Deformities of the Tibia, etc. British Journal of Radiology, **N.S. 16,** 371.

THE MANUBRIO-STERNAL JOINT IN ANKYLOSING SPONDYLITIS*

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The available information on the morbid anatomy of ankylosing spondylitis is largely concerned with the late stages when the joints have undergone bony ankylosis. The object of this paper is to draw attention to the changes which occurred in a readily accessible superficial cartilaginous joint [synchondrosis], namely the manubrio-sternal joint, in 72 per cent of sixty-one cases which have been studied.

The earliest post-mortem report appears to be that of Connor (1705), followed 172 years later by a more detailed naked-eye description by Fagge (1877). Guntz (1933) performed an autopsy in an early case and drew attention to changes in the spinal articulations varying from synovitis with round-cell infiltration, hyperaemia and connective tissue proliferation to final bony ankylosis. Freund (1942) described in detail the histological findings in part of the lumbar spine of a man aged sixty-seven who died of a hypernephroma, but neither the clinical details presented nor the gross pathological picture confirm the diagnosis of ankylosing spondylitis. Scott (1942) attempted to obtain pathological data by paracentesis of the sacro-iliac joint, but apart from failure to culture organisms from the material, he arrived at no conclusions. Polley and Slocumb (1947) found the histological changes characteristic of rheumatoid arthritis in the synovial membrane of the hip joint and their findings have been confirmed by Collins (1949). Simpson and Stevenson (1949), Desmarais, Gibson and Kersley (1948), Hart, Robinson, Allchin and Maclagan (1949) have all performed muscle biopsies with negative results. There appears to be no record of authentic autopsy findings during the early active stage of the disease.

Normal anatomy—The manubrio-sternal joint is a cartilage joint [synchondrosis] between the manubrium and the body of the sternum [corpus sterni]. At the lateral extremities are the costal articulations of the second ribs. According to Gray (1949) the joint occasionally becomes ossified in advanced life, but Blair (1943) has stated that this is exceptional and Brailsford (1948) agreed that the manubrium remains as a separate bone usually throughout life.

The joint can be demonstrated in radiographs by two projections: an oblique postero-anterior and a direct lateral. The latter gives the clearer definition, but, because of the greater lateral width than depth of the joint, a pathological process will appear less extensive than in the postero-anterior view. The lateral projection has been adopted for the purpose of this investigation.

In the normal joint (Figs. 1 to 3) the opposing surfaces of the manubrium and the body of the sternum are of equal proportions, smooth in outline and separated by a zone of translucency occupied by fibrocartilage. The surfaces are usually convex but are occasionally slightly concave. In either circumstance the bone margins are clearly outlined. The picture may be confusing when the second ribs throw oblique shadows over part of the joint and especially when there is calcification in the costal cartilages.

THE JOINT IN ANKYLOSING SPONDYLITIS

It has been known for some time that tenderness to pressure is present over certain bony prominences in most patients in the acute phase of ankylosing spondylitis. In 1942 the writer's attention was directed to the manubrio-sternal joint of a patient who had pain and

* Paper read at the meeting of the British Orthopaedic Association in Cardiff, April 1950.

tenderness in the sternum (Fig. 4). It seemed that a study of the disease process in so superficial a joint might be of value. Accordingly radiographs of the manubrio-sternal joint in the sixty-one cases of ankylosing spondylitis under treatment since 1942 have been examined. It was found that a destructive process involving both cartilage and adjacent bone surfaces is frequent. An initial transient period of loss of bone outline involving the manubrium, the

FIG. 1

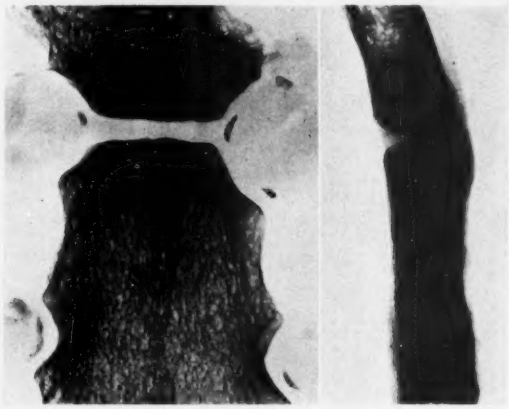

FIG. 2

Figure 1—Radiograph of normal manubrio-sternal joint showing smooth outline of opposing surfaces of manubrium and sternum. Figure 2—Radiographs of normal manubrio-sternal joint: autopsy specimen.

FIG. 3

Section of a normal manubrio-sternal joint from a woman aged eighty-three. (×6.) A cleft is present in the joint cartilage.

body of the sternum, or both, is followed by a period of creeping erosion which may produce an appearance of extensive excavation of both bone ends: the process appears to be limited by a zone of sclerosis similar to that seen in the sacro-iliac joints. Later, bony fusion begins at the periphery and slowly progresses until after many years all evidence of the original joint may have disappeared (Figs. 5 to 8).

To determine the development of the disease process the findings have been analysed by classifying the radiographic appearances according to the duration of the disease. The onset has been regarded as coincident with the first complaint of low backache (Table I).

Of the sixty-one cases reviewed fourteen showed a normal synchondrosis. These cases were distributed fairly evenly over the duration periods of the disease up to ten years and over, indicating that the joint may remain unaffected. Nevertheless only two normal joints

TABLE I

RADIOGRAPHIC CHANGES IN THE MANUBRIO-STERNAL JOINT AND IN THE SACRO-ILIAC JOINTS IN ANKYLOSING SPONDYLITIS

Analysis of sixty-one cases classified according to the duration of the disease

MANUBRIO-STERNAL JOINT						
Duration of disease (years)	Normal	Osteoporosis	Erosion	Incomplete fusion	Fusion	*Total*
0–1	3	1	1	2	—	7
1–2	2	1	2	—	—	5
2–4	3	—	7	2	1	13
4–6	2	—	3	1	1	7
6–8	2	—	—	2	3	7
8–10	1	—	—	2	3	6
10+	1	—	3	6	6	16
Total	14	2	16	15	14	61
SACRO-ILIAC JOINTS						
Duration of disease (years)	Normal	Osteoporosis	Erosion	Incomplete fusion	Fusion	*Total*
0–1	1	3	2	2	—	8
1–2	—	—	2	2	—	4
2–4	—	—	9	2	2	13
4–6	—	—	4	1	2	7
6–8	—	—	2	2	3	7
8–10	—	—	—	2	4	6
10+	—	—	—	—	16	16
Total	1	3	19	11	27	61

were found among the twenty-two cases in which the disease had been present for over eight years. This suggests that the longer the duration of the disease the less likely is the joint to remain normal. Osteoporosis, with loss of definition at the joint margins, was seen in two cases; it is a transient phase. Erosion of the opposing bone ends was noted in sixteen cases and occurred with greatest frequency during the first four years. Thereafter, bony fusion gradually supervened. The presence of erosion in three cases of over ten years' duration indicates either local arrest or late involvement of the manubrio-sternal joint.

FIG. 4
Erosion of manubrio-sternal joint in a man aged twenty-six years. Ankylosing spondylitis. Symptoms for two years.

FIG. 5
Osteoporosis of manubrium and corpus sterni in a man aged twenty years. Ankylosing spondylitis. Symptoms for two years.

FIG. 6
Erosion of the manubrio-sternal joint surfaces in a man aged thirty-six years. Ankylosing spondylitis. Symptoms for four years.

FIG. 7
Incomplete fusion of the joint in a man aged thirty-six years. Symptoms for only four months, but disease probably of long standing.

FIG. 8
Complete fusion of the manubrio-sternal joint in a man aged forty-five years. Ankylosing spondylitis. Symptoms for eleven years.

Although only 23 per cent of the sixty-one patients investigated had a normal manubrio-sternal joint it would be inaccurate to assume therefrom that the remaining 77 per cent had developed the pathological changes of ankylosing spondylitis; for the abnormality may have been due to other causes.

Control studies—Radiographs of the manubrio-sternal joint in 100 male subjects not suffering from ankylosing spondylitis or rheumatoid arthritis were examined. They were divided into five age groups of ten years each, ranging from fifteen to sixty-four, with twenty subjects in each group. Four joints showed slight reduction in thickness of the fibrocartilage; in seven there was some irregularity of the opposing ends. These eleven cases have been disregarded because the changes bore no resemblance to those of ankylosing spondylitis. Seven of them occurred in the forty controls over the age of forty-five, whereas only eight

FIG. 9

FIG. 10

Figure 9—Radiograph of the manubrio-sternal joint of a man aged twenty-six, suffering from ankylosing spondylitis with symptoms of three years duration. The joint appears normal. Figure 10—Three years and four months later there was marked erosion and narrowing of the joint.

patients with ankylosing spondylitis were in this age period and in all of them the manubrio-sternal joint was completely or almost completely fused. Three radiographs of the control series showed changes that could be confused with those of ankylosing spondylitis in the stage of incomplete fusion. In four of the control series the joint was fused. If correction is made for these seven cases of normal ageing of the joint the incidence of manubrio-sternal involvement in ankylosing spondylitis is 72 per cent.

Progress—There was little alteration in the majority of cases followed over a three-year period. In one patient with early erosion of the joint the disease appeared to have been arrested after five and a half years. Two others, observed for seven years, progressed from erosion to incomplete fusion. Late involvement was well demonstrated in one instance (Figs. 9 and 10).

Rheumatoid arthritis—We have studied radiographs of the manubrio-sternal joint in twenty-two patients, twenty-five to sixty-four years of age, with typical polyarticular

rheumatoid arthritis. Thirteen had a normal joint. Four showed diminution in height of the fibrocartilage with or without slight irregularity of the bone ends. Five joints were incompletely or completely fused. In none of the twenty-two cases of rheumatoid arthritis was there any evidence of the characteristic erosion seen in the spondylitic series. These findings suggest that the natural process of fusion which may take place in normal individuals occurs more frequently in rheumatoid arthritis. A larger series, however, should be investigated.

Discussion—Comparison of the radiographic appearances of the manubrio-sternal joint in ankylosing spondylitis, in rheumatoid arthritis, and in healthy subjects (Table II), shows a striking incidence of pathological changes, leading up to complete fusion, in ankylosing spondylitis. Thus in the twenty-one patients with ankylosing spondylitis over the age of thirty-five, every joint showed abnormality in the form of fusion, incomplete fusion or erosion. Of the corresponding sixty controls, only seven showed abnormality in the form of complete or incomplete fusion. A further eight showed slight irregularity of the bone ends and reduction in cartilage height, probably the early stage of normal ageing. In the patients with rheumatoid arthritis there is evidence that the joint becomes ankylosed more frequently and at an earlier age than in normal individuals.

Comparison of changes in manubrio-sternal and sacro-iliac joints—Although it is hardly possible to compare cartilaginous joint [synchondrosis] with a synovial [diarthrodial] joint, it may be suggested that a similar pathological process occurs in the manubrio-sternal and sacro-iliac joints. A comparison of the radiographs of these in the sixty-one cases under review is of interest. In Table I the sacro-iliac changes have been classified with those of the manubrio-sternal joint. Comparison shows that the general pattern of progress of the disease, in relation to its duration, is similar in each joint.

HISTOLOGICAL STUDIES

The recognition of a pathological process in so superficial a joint as the manubrio-sternal presents a valuable opportunity for the study of the histological changes in the disease. Biopsy has been undertaken in five cases. In four, the radiographs demonstrated erosion, and in one the joint was fused. Through a short vertical incision, placed directly over the joint, a section was removed comprising the distal extremity of the manubrium, the joint cartilage and the proximal extremity of the body of the sternum. The sections included rather more than half of the total antero-posterior depth.

In the four cases of erosion, the most notable features were areas of replacement of fibrocartilage by collagenous fibrous tissue spreading into the bone (Figs. 11 to 14). The absence of inflammatory reaction was striking. The fibrous tissue was well formed and of adult type. It probably arose in the cartilage and involved the bone ends later. In some areas there was evidence of osteoclastic activity. The areas of erosion appeared to be limited by a narrow zone of sclerosis. No haemopoietic marrow was seen. Sections of the fused joint showed direct replacement of cartilage by bone. Remnants of cartilage remained, however, and zones of collagenous fibrous tissue were seen in the bone interstices. Histological examination of the manubrio-sternal joints of elderly subjects from the post-mortem room revealed no fibrous tissue formation. Collagenous fibrous tissue is found in the late stages of ankylosis of synovial joints in rheumatoid arthritis, but no evidence of fibrous replacement was seen in the section of the manubrio-sternal joint of the one rheumatoid subject investigated.

DISCUSSION

Our investigations have disclosed an abnormal state of the manubrio-sternal joint in ankylosing spondylitis which may be of interest in the further study of the disease. Previously, the detailed histological study of the early stages of the disease process has been handicapped by the inaccessibility of the sacro-iliac joints for biopsy purposes and by the fact that opportunities for autopsy examination in an early case are very seldom presented.

The earliest radiographic evidence of ankylosing spondylitis is almost always to be found in the sacro-iliac joints. The subsequent changes in these joints are similar to those in the manubrio-sternal joint. It is agreed by most observers that subchondral changes are present in the sacro-iliac area; and radiographs of the manubrio-sternal joints may show subchondral osteoporosis which gives the appearance of increased depth of the joint. Subchondral fibrosis

TABLE II

RADIOGRAPHIC CHANGES IN THE MANUBRIO-STERNAL JOINT IN ANKYLOSING SPONDYLITIS, IN RHEUMATOID ARTHRITIS AND IN HEALTHY CONTROL SUBJECTS,

Analysis of sixty-one subjects classified by age

ANKYLOSING SPONDYLITIS						
Age group	Number of cases	Fusion	Incomplete fusion	Erosion	Osteoporosis	Irregularity and thinning of joint
15–24	10	—	1	2	1	—
25–34	30	6	5	10	1	1
35–44	13	2	7	4	—	—
45–54	5	4	1	—	—	—
55–64	3	2	1	—	—	—
RHEUMATOID ARTHRITIS						
Age group	Number of cases	Fusion	Incomplete fusion	Erosion	Osteoporosis	Irregularity and thinning of joint
15–24	—	—	—	—	—	—
25–34	4	—	1	—	—	1
35–44	7	1	—	—	—	2
45–54	6	1	1	—	—	1
55–64	5	1	—	—	—	—
HEALTHY CONTROLS						
Age group	Number of cases	Fusion	Incomplete fusion	Erosion	Osteoporosis	Irregularity and thinning of joint
15–24	20	—	—	—	—	1
25–34	20	—	—	—	—	2
35–44	20	2	1	—	—	1
45–54	20	1	—	—	—	1
55–64	20	1	2	—	—	6

has been demonstrated in the biopsy specimens. Collins (1949) detected union of the sacro-iliac joints " partly by bone and partly by fibrous tissue of so bland an appearance that it might have represented the normal interarticular ligament, had it not been for the survival of islets of articular cartilage and the irregular advance of ossification from either side." This appears to be essentially the same process that we found in the manubrio-sternal joint in our cases.

Inflammatory synovial changes characteristic of rheumatoid arthritis were found in the

FIG. 11

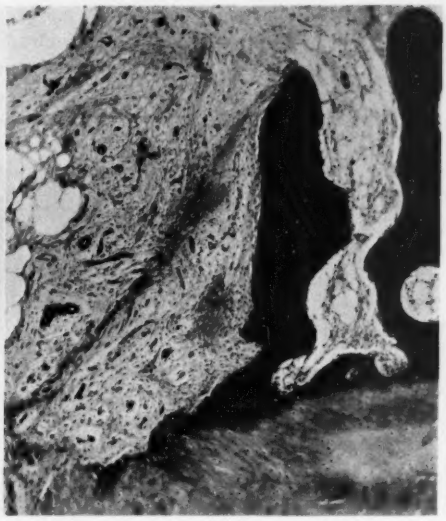

FIG. 12

Figure 11—Section from biopsy through the joint shown in Figure 10. (×6.) The large spaces in the cancellous bone and the joint space near the posterior line of section (left centre) are filled with fibrous tissue. Note the absence of haemopoietic marrow (*cf.* Fig. 3). Figure 12—High-power view of the ringed area in Figure 11. (×49.) The marrow space is filled with loose, vascular fibrous tissue. There is no inflammatory reaction.

FIG. 13

FIG. 14

Figure 13—Section from biopsy through anterior part of the manubrio-sternal joint of a woman aged thirty-four years, suffering from ankylosing spondylitis. (×4½.) Fibrous tissue occupies the lower part of the joint anteriorly (right lower centre) and sweeps backwards and upwards far into the manubrium. The radiographic appearance was that of extensive erosion. Figure 14—High-power view of the ringed area in Figure 13. (×49.) The fibrous tissue is much more compact than in Figure 12.

hip joint of one of our patients. Similar findings have been described by Collins (1949) in the hip joint and by Guntz (1933) in the spinal articulations. Inflammatory reaction was not found in the manubrio-sternal joint in the five cases which we examined.

The increase of antero-posterior depth of the manubrio-sternal joint as ankylosis progresses is worthy of note. Osseous union begins at the periphery by beaking, and the process is similar to that which occurs in the annulus fibrosus of the intervertebral discs, as described by Collins.

The symphysis pubis, a joint similar to the manubrio-sternal, sometimes shows abnormality. Erosion has not been observed by the writer but peripheral ossification occasionally occurs.

Whatever the true nature of the early lesion in ankylosing spondylitis, it is followed in the manubrio-sternal joint by a process of fusion that is seen in only a small percentage of normal individuals.

SUMMARY

1. Pathological changes occurred in the manubrio-sternal joint in 72 per cent of a series of sixty-one cases of ankylosing spondylitis.

2. In all the twenty-one patients over the age of thirty-five years the joint was undergoing a process of fusion that was found in only seven of sixty healthy persons in the same age group.

3. In the age groups twenty-five to forty-four, thirty-five out of forty-three patients with ankylosing spondylitis showed abnormality that was noted in but three of the forty healthy controls.

4. The changes in the manubrio-sternal joint are similar to those which occur in the sacro-iliac joint.

5. The accessibility of the manubrio-sternal joint makes it a convenient source of pathological material for the further histological study of the disease.

I wish to express my thanks to Mr I. S. Smillie for his encouragement, criticisms and advice; and to Dr Bruce Cruickshank, of the Pathology Department of Edinburgh University, who has given much of his time to the study of the pathological material.

REFERENCES

BLAIR, D. M. (1943): Arthrology. Cunningham's Text-book of Anatomy. Eighth edition. London: Oxford University Press, 340.

BRAILSFORD, J. F. (1948): The Radiology of Bones and Joints. Fourth edition. London: J. & A. Churchill Ltd., 463.

COLLINS, D. H. (1949): The Pathology of Articular and Spinal Diseases. London: Edward Arnold & Co., 313.

CONNOR, B. (1705): The Bones, Joints and Muscles. Philosophical Transactions and Collections, Abridged, London, **3,** 293.

DESMARAIS, M. H. L., GIBSON, H. J., and KERSLEY, G. D. (1948): Muscle Histology in Rheumatic and Control Cases: A Study of One Hundred and Nineteen Biopsy Specimens. Annals of the Rheumatic Diseases, **7,** 132.

FAGGE, C. HILTON (1877): Transactions of the Pathological Society of London, **28,** 201.

FREUND, E. (1942): A Contribution to the Pathogenesis of Spondylitis Ankylopoietica. Edinburgh Medical Journal, **49,** 91.

GRAY, H. (1949): Anatomy Descriptive and Applied. Thirtieth edition. London: Longmans, Green & Co., 459.

GUNTZ, E. (1933): Beitrag zur pathologischen Anatomie der Spondylarthritis Ankylopoetica. Fortschritte auf dem Gebiete der Rontgenstrahlen, **47,** 683.

HART, F. DUDLEY, ROBINSON, K. C., ALLCHIN, F. M., and MACLAGAN, N. F. (1949): Ankylosing Spondylitis. Quarterly Journal of Medicine, **N.S. 18,** 217.

POLLEY, H. F., and SLOCUMB, C. H. (1947): Rheumatoid Spondylitis: A Study of 1,035 Cases. Annals of the Rheumatic Diseases, **6,** 95.

SCOTT, S. G. (1942): Adolescent Spondylitis. London: Oxford University Press, 61.

SIMPSON, N. R. W., and STEVENSON, C. J. (1949): An Analysis of 200 Cases of Ankylosing Spondylitis. British Medical Journal, **i,** 214.

THE MONTEGGIA FRACTURE WITH POSTERIOR DISLOCATION OF THE RADIAL HEAD

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Formerly of the Bristol Royal Infirmary

There are two varieties of the fracture-dislocation originally described by Monteggia (1814), according to whether the head of the radius is dislocated anteriorly or posteriorly. The anterior variety, which is the more common, has received a prominent place in all text-books on fractures, chiefly on account of the frequency with which the dislocation is overlooked (Speed and Boyd 1940, Watson-Jones 1943). The posterior variety, however, has received much less attention and there are few references to it in the literature. Most authorities put the incidence of the posterior variety at 10 to 15 per cent but in a series of ten Monteggia fractures treated during the last year at the Bristol Royal Infirmary no fewer than seven had posterior dislocations of the radial head.

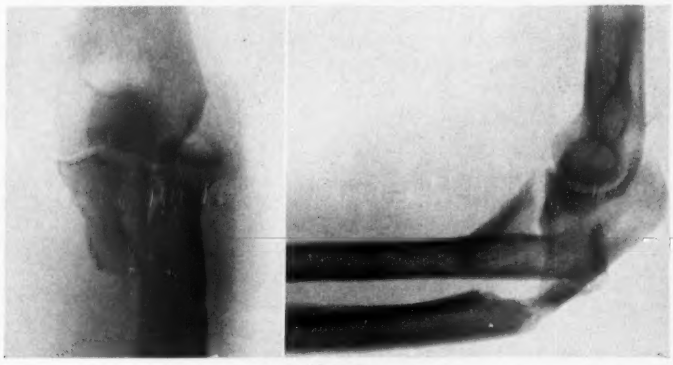

FIG. 1

The typical injury. Note the fracture of the ulna with anterior comminution and posterior angulation, the posterior and lateral displacement of the upper end of the radius, and the fracture of the head of the radius.

Age and sex incidence—There were five women and two men in the group. In all five women the radiographic appearances were almost identical, but the two men did not follow the pattern so closely. The average age was forty-eight years. Unlike the anterior Monteggia fracture, which occurs frequently in children, this is essentially an injury of middle age, and women seem particularly susceptible.

PATHOLOGY

The fracture of the ulna—There is a fracture of the ulna about one inch distal to the coronoid process, with a separate triangular or quadrilateral fragment displaced anteriorly (Fig. 1). Several smaller fragments also are usually present on the subcutaneous aspect, but are seldom well seen in the radiograph. There is posterior angulation at the site of fracture, and the distal fragment is displaced towards the radius. (In the more usual anterior type of Monteggia fracture it is the proximal fragment that is displaced towards the radius.) In the five female

FIG. 2

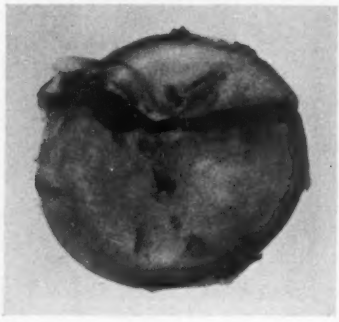

FIG. 3

Radiograph (Fig. 2) and photograph (Fig. 3) of a specimen showing the usual injury to the radial head in the posterior Monteggia fracture.

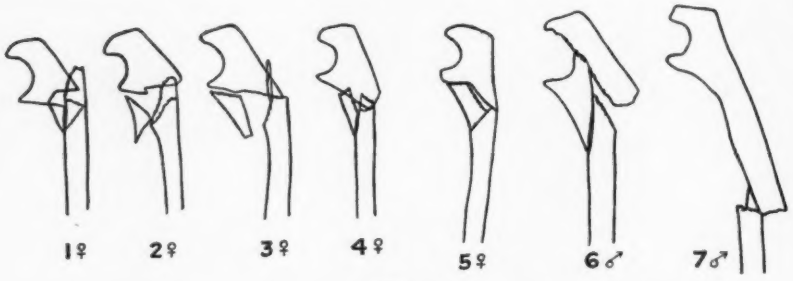

FIG. 4

Tracings of the ulnar fracture in seven cases of posterior Monteggia fracture. (The main fragments only are shown.)

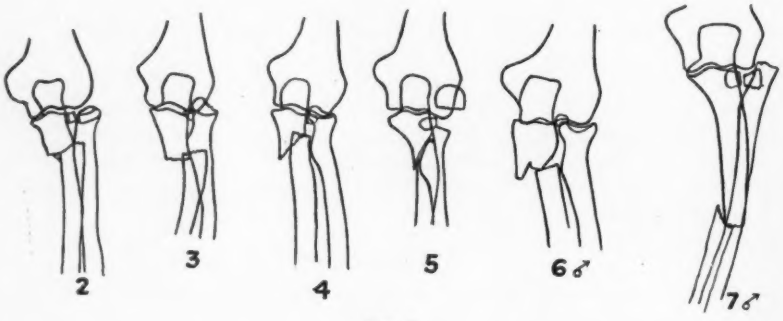

FIG. 5

Tracings showing the pattern of the fracture as seen in the antero-posterior radiographs of six patients with posterior Monteggia fracture. Note the constant position of the detached fragment of the radial head, the lateral displacement of the shaft of the ulna (except in Case 7) and the lateral subluxation of the head of the radius.

patients the fracture of the ulna followed this pattern closely (Fig. 4). In one of the men there was a slight variation in that the anterior triangular fragment was larger than usual and included the major part of the articular surface of the trochlear notch [greater sigmoid cavity]. The other man had a simple fracture of the midshaft of the ulna, such as is often seen in the anterior Monteggia fracture. In this case the mechanism of the injury was different from that in the other six.

The injury to the radius—The radial head is dislocated posteriorly and the annular [orbicular] ligament is ruptured, or avulsed with its bony attachment. In four of the seven cases there was a lateral subluxation as well and in every case there was a fracture of the radial head (Figs. 2 and 3). In four cases out of seven this was a fracture of the anterior margin, which had clearly been sheared off by the capitulum [capitellum] as the dislocation occurred. The detached fragment of the radial head lay anteriorly and could be seen between the radius and ulna (Fig. 5). In the other three cases there was a fracture through the neck of the radius in addition to the anterior marginal fracture, so that the broken radial head lay free in the joint in two pieces.

The injury to the humerus—In two cases obvious damage to the articular surface of the capitulum was noticed at operation.

FIG. 6

In this radiograph, taken in the position of displacement, the defective segment of the radial head is directed anteriorly. The forearm was in 30 degrees of pronation.

MECHANISM OF THE INJURY

Patients' statements regarding the position of the limb at the time of injury notoriously lack detail and the patients in this series could say no more than that they "just fell on the arm," one from a height of twelve feet, one from the top of a gate, one from a chair and the others from ground level. One man—with the atypical fracture already referred to—had caught his arm in a hydraulic jack. Very little help as to the mechanism of the injury was gained from the patients' statements.

Evans (1949) has drawn attention to the role of excessive pronation in the production of the anterior Monteggia fracture, and if the posterior variety is to be considered as the counterpart of this injury it is tempting to suggest that forcible supination might play a part in its production. In fact, however, excessive rotation in either direction does not enter into the mechanism at all.

The position of the fractured segment of the radial head affords evidence of the position of the forearm at the moment of impact. Clearly this segment is sheared off by the capitulum as the posterior dislocation occurs (Fig. 6). The position at the time of injury can therefore be determined by placing the forearm in that degree of rotation in which the missing segment faces directly forwards. This can most easily be observed at the time of operation if the radial head or its displaced segment is being removed, but it can be determined also from lateral radiographs taken in varying positions of rotation until the position is found where the fractured segment faces directly forwards. Figure 6 shows a lateral radiograph of an elbow in the dislocated position. The fractured segment of the radial head is facing forwards, and is in contact with the capitulum which sheared it off. The forearm was, therefore, in this position of rotation at the moment of impact; it was neither fully pronated nor fully supinated, but approximately in the mid-position. This was confirmed at operation, which showed that the position was in fact about 30 degrees of pronation. This degree of pronation corresponds to that observed when the hand is placed on the floor with the elbow slightly

FIG. 7

FIG. 8

FIG. 9

Figure 7—Position of the arm for the experiment described in the text. (Skeleton only is shown for the sake of clarity.) Figure 8—The first effect produced by violence in the axis of the forearm was a posterior dislocation of the forearm. Figure 9—after weakening the upper end of the ulna by notching the anterior cortex the same violence produced nearly all the features of the posterior Monteggia fracture.

flexed, and held well away from the side as in a fall on the hand. In all four cases in which simple marginal fractures occurred there were similar findings and in no case was the arm fully pronated or fully supinated. In the remaining three cases the radial head was completely detached and gave no clue as to its position at the time of injury. The displacement of the radial head posteriorly or postero-laterally invites comparison with the displacement in a dislocated elbow, and it appears likely that the posterior Monteggia fracture is simply a variation of the dislocated elbow, in which the ligamentous attachments of the elbow prove stronger than the shaft of the ulna, and the shaft therefore fractures. In the dislocated elbow the reverse is the case. This hypothesis was tested experimentally by placing a dissecting-room specimen on a rigid support with the elbow at 120 degrees and the forearm in moderate pronation (Fig. 7). The hand was amputated through the wrist and a violent blow was delivered on the distal end of the radius and ulna. As had been expected, the result was a posterior dislocation of the elbow (Fig. 8). But when the upper end of the ulna was deliberately weakened by notching its anterior cortex a similar force reproduced nearly all the typical features of the injury under discussion—namely, a fracture of the ulna with comminution anteriorly and posterior angulation; posterior dislocation of the radial head; and marginal fracture of the radial head (Fig. 9). Under the conditions of the experiment the fracture of the ulna was to be expected and is of no particular significance, but the fracture and dislocation of the radial head, so exactly resembling the clinical condition, does indicate that the mechanism described can produce this injury. The effects of excessive supination and of forcible abduction were also tried, but did not reproduce this pattern of injury.

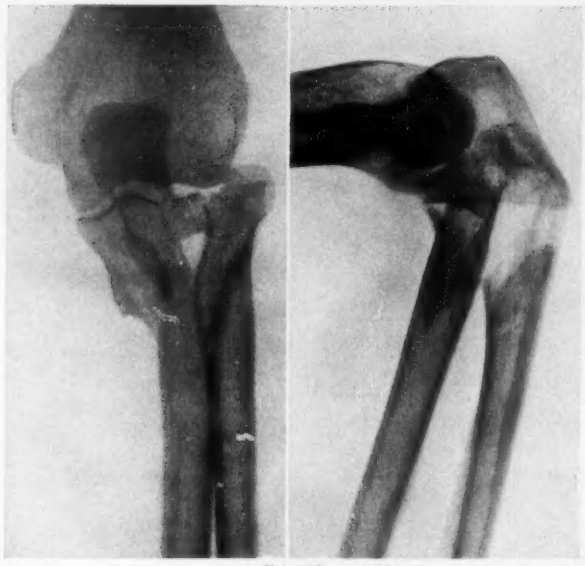

FIG. 10

Case 2—Radiographs of the elbow before reduction. The head of the radius lies free in the joint in two pieces.

FIG. 11

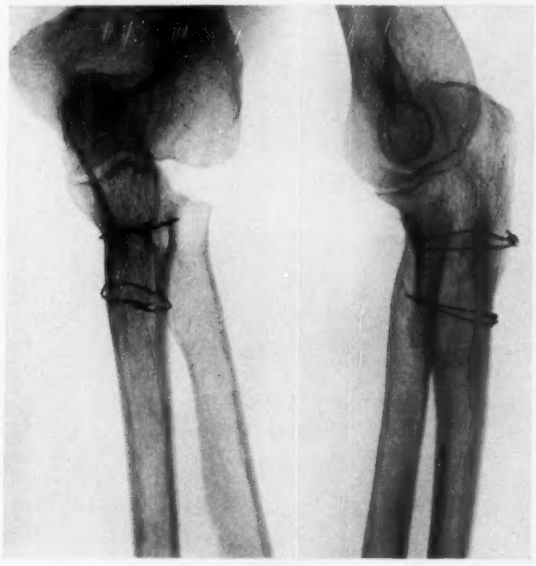

FIG. 12

Case 2. Figure 11—After excision of the head of the radius and internal fixation of the ulna. Figure 12—Three months later, after removal of the intramedullary wire.

FIG. 13
Case 3—Radiographs before reduction.

FIG. 14
Case 3—After excision of the detached fragment of the head of the radius and internal fixation of the ulna.

FIG. 15
Case 3—After removal of the intramedullary wire. Despite imperfect reduction of the ulna good function and mobility were regained.

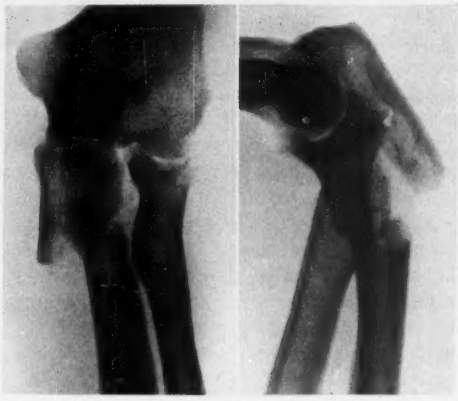

FIG. 16

Case 5—Before reduction. The pattern of the fracture is not quite typical. The triangular anterior fragment is larger than usual and involves most of the greater sigmoid notch.

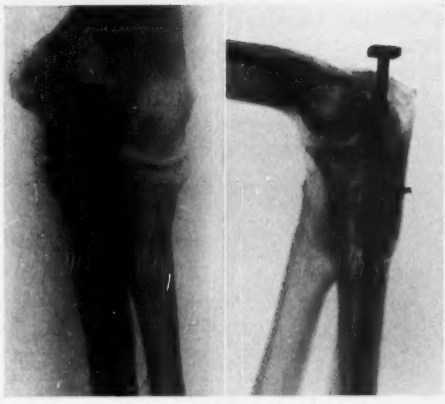

FIG. 17

Case 5—After excision of the displaced fragment of the radial head and intramedullary nailing.

FIG. 18

Case 5—After removal of the nail. Union is sound.

TREATMENT

Immobilisation in plaster with the elbow extended and the forearm supinated has been recommended for the treatment of this injury. In the cases in which we used this method, it did not produce a good reduction; it tended to increase the forward displacement of the triangular fragment of the ulna to which the brachialis is attached, and it did not prevent the displacement of the distal fragment towards the radius. Moreover, all these injuries occurred in middle-aged people in whom immobilisation of a severely injured elbow in extension for perhaps three months might seriously prejudice the chances of regaining a good range of flexion. These hazards can be obviated by internal fixation of the ulna, especially as operation is necessary in most cases for the fractured head of the radius.

Technique of operation—The joint is exposed through a postero-lateral incision. According to the degree of damage to the head of the radius and the capitulum, either the whole radial head or the displaced fragment is excised and the dislocation is reduced. Only if the displaced segment is small and the rest of the joint normal should the segment alone be removed. The joint is closed and the ulnar fracture is exposed by extending the skin incision along the subcutaneous border of the ulna. In most cases the upper fragment is not large enough to permit plating, and consequently intramedullary wire or nail fixation has usually been relied upon. In addition one or two loops of stainless steel wire have been used to maintain the reduction of the comminuted fragments. If fixation is rigid, plaster can be dispensed with and active movements may be started as soon as the wound is soundly healed. The intramedullary wire or nail is removed after the fracture has united. The only difficulty in the operation is to reduce the displaced anterior fragment of the ulna; but even if reduction is imperfect the result may be satisfactory.

Illustrative radiographs are shown in Figures 10 to 18.

TABLE I

FINAL RANGE OF ELBOW MOVEMENT

Case	Angle at elbow (degrees)		Range (degrees)	Pronation	Supination
	Flexed	Extended		(in degrees from neutral rotation)	
1	75	160	85	23	45
2	55	160	105	90	77
3	65	150	85	90	30
4	75	140	65	90	30
5	45	180	135	81	90
6	65	165	100	81	30
7	65	165	100	90	45
Average	64	160	96	78	50

RESULTS

There has been some residual disability in all cases (Table I), but it has been relatively slight when the severity of the injury is considered. It is to be expected that the results will be inferior to those following the anterior Monteggia fracture, in which the radial head is seldom, if ever, fractured and which frequently occurs in very young people.

Slight restriction of flexion and extension and some limitation of supination have been usual. Pronation and supination seem slightly better in those cases in which the whole radial head has been excised. This may prove to be the better treatment in all cases.

CONCLUSIONS

1. The posterior Monteggia fracture usually conforms to a typical pattern.
2. Its incidence is greatest among middle-aged women.
3. The mechanism of the injury is probably similar to that of the dislocated elbow. Excessive rotation of the forearm plays no part in its production.
4. Internal fixation of the ulna combined with excision of the whole radial head, or of its detached segment, is suggested as the treatment of choice.
5. The functional results after operation are excellent, but some slight permanent restriction of movement is to be expected.

I am indebted to Mr A. L. Eyre-Brook for helpful advice and criticism during the preparation of this article, and to Professor J. M. Yoffey of the Department of Anatomy, University of Bristol, for facilities for the experimental work.

REFERENCES

EVANS, E. M. (1949): Pronation injuries of the forearm. Journal of Bone and Joint Surgery, **31–B,** 579.
MONTEGGIA, G. B. (1814): Instituzioni Chirurgiche. Second edition. Milan: G. Maspero.
SPEED, J. S., and BOYD, H. B. (1940): Treatment of fractures of ulna with dislocation of head of radius. Journal of the American Medical Association, **115,** 1699.
WATSON-JONES, R. (1943): Fractures and Joint Injuries. Third edition. Edinburgh: E. & S. Livingstone Ltd., **2,** 520.

SOME EXPERIENCES IN THE TREATMENT OF OSTEOMYELITIS OF INFANTS

An Evaluation of the Results of Treatment by Penicillin

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From the Hospital for Sick Children, Paris

The introduction of penicillin altered very considerably the existing conceptions of treatment of acute osteomyelitis. As far as children and adults are concerned the results of treatment with penicillin have been carefully studied and evaluated in many published papers. But so far as we are aware the efficacy of penicillin in the treatment of acute osteomyelitis of *infants* has not been fully investigated. The purpose of this paper is to present our experiences with seventeen cases of acute osteomyelitis in patients under two years of age treated with penicillin and to compare the results with forty-eight similar cases treated by earlier methods.

Clinical material—Sixty-five cases of acute osteomyelitis in children under two years of age have been studied. Seventeen patients were treated by systemic penicillin injections, and forty-eight by older methods. There was no selection of patients for either group. The only factor which determined the method used was the availability of penicillin at the time the patient was admitted. (During the period of this investigation—1946–48—supplies of penicillin were extremely short. This explains the numerical inequality of the two groups.)

The age at the time of admission was from nineteen days to twenty-four months. Twenty-six of the sixty-five patients were under three months old, a high incidence in early infancy which accords with the view that during the first few months of life resistance to pyogenic organisms has not yet been built up and the liability to osteomyelitis is great.

Details of treatment. *Penicillin group*—Penicillin was given by repeated intramuscular injections. Although sterile abscesses have been reported in young children so treated (Bodian 1945), we have not observed any complications attributable to the injections.

Dosage—At first we graded the dose of penicillin according to the body-weight, giving 1000 units per pound of body-weight as recommended by Bodian (1945). Our experience suggested that this dose was seldom effective and we resorted later to much larger doses.

Duration of treatment—McAdam (1945) has shown by repeated aspiration of the bone marrow in cases of acute osteomyelitis that neither the temperature chart nor the leucocyte count gives a reliable indication of the time needed for the sterilization of the bone. Organisms may be demonstrated in a metaphysis for more than two weeks, despite an apparently favourable response. Administration of penicillin should therefore be continued for at least three weeks. According to McAdam's calculations an infant three months old should receive a total of 150,000 units. At six months old the total dose should be 200,000 units; at twelve months, 300,000 units; and at two years, 400,000 units. In most of our cases we have greatly exceeded these recommended doses and have continued the treatment for a much longer period. Systemic injections of penicillin were combined with: immobilisation of the limb; continuous traction (in some cases); aspiration or incision of an abscess (sometimes followed by local instillation of penicillin); and sequestrectomy when indicated. In a few cases manipulation or operative correction of a deformity has been necessary.

Control group—The forty-eight patients who did not receive penicillin were treated by immobilisation in a plaster or metal splint; wet compresses; blood transfusion; aspiration or incision of abscesses; and sequestrectomy when indicated. Correction of deformity by manipulation or operation was occasionally required.

CASE REPORTS

Case 1—J. B., aged eleven months. Acute osteomyelitis of the humerus. Administration of penicillin begun forty-eight hours after the onset. Blood culture negative. Pyrexia persisted many days then fell gradually; it appeared to be little influenced by the penicillin. Resolution without suppuration or major bone lesions. Total dosage of penicillin—1,000,000 units.

Case 2—D. M., aged five months. Acute osteomyelitis of the tibia. Leucocytes 12,200 per cubic millimetre. Blood culture negative. Treatment begun two weeks after onset. Pyrexia subsided rapidly. Resolution without suppuration or major bone lesions. Total dosage of penicillin—1,000,000 units.

Case 3—S. I., aged seven weeks. Acute osteomyelitis of the fibula. Leucocytosis 11,600. Blood culture negative. Treatment begun nine days after onset. Temperature fell three days later. Penicillin injections continued for nineteen days. Five days after the injections had been discontinued (thirty-three days after onset) an abscess appeared. Incision. Culture of pus yielded staphylococcus aureus. The collection dried up three months later. In spite of the suppuration there were no gross bone changes. Total dosage of penicillin—1,240,000 units.

Case 4—L. P., aged two years. Acute osteomyelitis of the humerus. Leucocytosis 12,500. Blood culture negative. Penicillin treatment begun on the fifth day. No suppuration, but later radiographs showed marked bone changes. Total dosage of penicillin—1,750,000 units.

TABLE I

ANALYSIS OF SEVENTEEN CASES OF ACUTE OSTEOMYELITIS TREATED WITH PENICILLIN

No.	Name	Age	Localisation	Radiographic findings*	Total dose of penicillin	Condition on discharge	Duration of hospital treatment	Observations
1	J. B.	11 months	Humerus	++	1,000,000	Slight activity	37 days	—
2	D. M.	5 months	Tibia	+	1,000,000	Quiescent	37 days	—
3	S. I.	7 weeks	Fibula	+++	1,240,000	Quiescent	8 months	—
4	L. P.	2 years	Humerus	+++	1,750,000	Quiescent	3 months	—
5	O. G.	6 weeks	Femur	+++	1,500,000	Quiescent	4 months	—
6	A. L.	4 weeks	Tibia	+++	3,135,000	Quiescent	4 months	—
7	S. T.	22 months	Fibula	+++	4,450,000	Quiescent	6 months	Pericarditis. Spontaneous fracture
8	C. M.	8 months	Humerus	++	2,120,000	Quiescent	38 days	—
9	L. C.	3 weeks	Humerus	+++	700,000	Slight activity	30 days	—
10	E. B.	4 weeks	Ulna	+++	200,000	Quiescent	39 days	Urine culture: staphylococcus albus
11	M. J.	8 months	Humerus	++	2,500,000	Death	2 months	Fatty degeneration of liver
12	L. D.	8 months	Humerus		200,000	Death	3 days	—
13	L. R.	2 years	Femur	+	1,000,000	Quiescent	2 months	—
14	C. C.	2 years	Femur	+	300,000	Slight activity	12 days	—
15	T. N.	5 weeks	Femur		3,100,000	Death	23 days	—
16	B. R.	7 weeks	Femur	+++	3,600,000	Quiescent	5 months	—
17	L. I.	16 months	Multiple	+++	4,950,000	Quiescent	29 months	—

* Radiographic findings: + = changes limited to periosteum.
++ = rarefaction or cavitation of bone in addition to periosteal reaction.
+++ = gross changes involving a major part of the bone.

TABLE II

ANALYSIS OF FORTY-EIGHT CASES OF ACUTE OSTEOMYELITIS TREATED WITHOUT PENICILLIN

No.	Name	Age	Localisation	Radiographic findings*	Condition on discharge	Duration of hospital treatment	Observations
1	A. R.	21 months	Tibia	++	Quiescent	13 months	—
2	E. I.	10 months	Femur	++	Quiescent	5 months	—
3	P. G.	22 months	Multiple	+	Slight activity	5 months	—
4	N. L.	12 months	Femur	++	Slight activity	30 days	—
5	S. P.	9 months	Ribs	++	Quiescent	7 months	Multiple abscesses
6	I. L.	2 months	Humerus	+++	Quiescent	12 months	—
7	M. A.	21 months	Radius	+++	Quiescent	11 months	Sequestrum
8	M. B.	9 months	Humerus	++	Quiescent	5 months	—
9	M. D.	8 months	Hip	++	Quiescent	2 months	Subluxation
10	I. B.	16 months	Humerus	+++	Slight activity	41 days	—
11	I. C.	45 days	Humerus	++	Slight activity	22 days	Multiple abscesses
12	G. P.	4 months	Ulna	+	Slight activity	18 days	Multiple abscesses
13	I. P.	19 months	Metatarsals	+++	Quiescent	5 months	—
14	I. I.	3 months	Femur	+++	Quiescent	35 days	Sequestrum
15	M. B.	2 months	Tibia	+++	Quiescent	17 months	—
16	S. D.	24 months	Tibia	++	Quiescent	6 months	Spontaneous fracture
17	M. S.	22 months	Fibula	+++	Quiescent	17 months	Multiple abscesses
18	S. B.	11 months	Radius	++	Quiescent	16 months	Dislocation
19	I. B.	23 days	Multiple	+++	Quiescent	45 months	Sequestrum
20	R. R.	28 days	Multiple	+++	Slight activity	46 days	—
21	I. E.	14 months	Multiple	++	Slight activity	33 days	—
22	N. I.	22 days	Multiple	+++	Slight activity	30 days	—
23	M. L.	20 months	Multiple	+	Quiescent	38 days	—
24	I. R.	20 months	Multiple	+	Death	18 days	—
25	B. T.	3 months	Humerus	++	Death	14 days	Mastoiditis
26	B. M.	6 months	Humerus	++	Quiescent	4 months	Multiple abscesses
27	L. P.	12 months	Humerus	+	Quiescent	30 days	—
28	I. P.	5 months	Femur	+++	Quiescent	31 months	—
29	P. G.	14 months	Multiple	+++	Slight activity	4 months	Multiple abscesses
30	M. G.	30 days	Multiple	+++	Quiescent	2 months	Dislocation
31	I. L.	48 days	Multiple	+++	Quiescent	32 months	—

* Radiographic findings: + = changes limited to periosteum.
++ = rarefaction or cavitation of bone in addition to periosteum reaction.
+++ = gross changes involving a major part of the bone.

TABLE II—*continued*

ANALYSIS OF FORTY-EIGHT CASES OF ACUTE OSTEOMYELITIS TREATED WITHOUT PENICILLIN

No.	Name	Age	Localisation	Radiographic findings*	Condition on discharge	Duration of hospital treatment	Observations
32	A. A.	16 months	Humerus	+	Quiescent	30 days	Extra-periosteal abscess
33	P. M.	8 months	Radius	++	Quiescent	4 months	—
34	C. D.	2 months	Tibia	++	Slight activity	37 days	—
35	R. B.	5 months	Ribs	+++	Slight activity	15 days	Sequestrum
36	R. M.	21 months	Humerus	++	Quiescent	20 days	—
37	G. T.	30 days	Humerus	+++	Death	27 days	Sequestrum
38	C. P.	10 months	Femur	++	Quiescent	2 months	—
39	D. D.	5 months	Femur	++	Quiescent	33 days	—
40	G. S.	2 months	Multiple	++	Death	25 days	Fatty degeneration of liver
41	R. B.	2 months	Tibia	++	Slight activity	42 days	—
42	G. P.	2 months	Humerus	++	Quiescent	4 months	—
43	B. S.	4 months	Humerus	++	Quiescent	4 months	—
44	N. T.	14 months	Femur	++	Quiescent	30 days	—
45	M. P.	44 days	Humerus	+	Quiescent	2 months	—
46	N. S.	45 days	Femur	++	Quiescent	6 months	—
47	I. G.	2 months	Metatarsals	+	Quiescent	23 days	—
48	D. E.	5 months	Multiple	+++	Slight activity	2 months	—

* Radiographic findings: + = changes limited to periosteum.
++ = rarefaction or cavitation of bone in addition to periosteum reaction.
+++ = gross changes involving a major part of the bone.

Case 5—O. G., aged six weeks. Subacute osteomyelitis of the femur. Blood culture negative. Penicillin treatment begun on the eighth day. No suppuration, but later radiographs showed marked bone changes. Total dosage of penicillin—1,500,000 units.

Case 6—A. L., aged four weeks. Acute osteomyelitis of the tibia. Inflammatory lesions affecting forearm, wrist, hand, knee and foot of same side and thumb of opposite side. Leucocytosis 28,000. Blood culture—staphylococcus aureus. General condition poor; high temperature. Penicillin treatment begun on the third day. Two days later an abscess developed over the tibia. Aspiration. Culture of pus yielded staphylococcus and streptococcus. Five days later the abscess was incised. The early radiographs showed no significant changes but later films showed involvement of the whole length of the tibia. Chronic disease persisted. Total dosage of penicillin—3,135,000 units.

Case 7—S. T., aged twenty-two months. Subacute osteomyelitis of the fibula. Leucocytosis 13,500. Blood culture negative. Treatment begun on the fifth day. Three and a half weeks after the penicillin had been discontinued the general condition deteriorated. An abscess formed and was incised. Later, pericarditis developed. Large doses of penicillin were given again. Despite these complications, and a spontaneous fracture of the fibula, healing ultimately occurred. Total dosage of penicillin—4,450,000 units.

Case 8—C. M., aged eight months. Acute osteomyelitis of the humerus with extension to the elbow joint. Leucocytosis 15,600. Blood culture—staphylococcus aureus. Treatment begun on the eighth day. An abscess formed and was incised and a sequestrum was removed. Wound healed.

Pus culture—staphylococcus aureus. General condition fair. Pyrexia subsided by the sixteenth day. Radiographic changes were slight and did not progress. Total dosage of penicillin—2,120,000 units.

Case 9—L. C., aged three weeks. Acute osteomyelitis of the humerus with extension to the elbow joint. Treatment begun on the eighth day. Abscess incised. Culture of pus yielded staphylococcus. Progress was satisfactory but the patient left the hospital before completion of treatment. Total dosage of penicillin—700,000 units.

Case 10—E. B., aged four weeks. Acute osteomyelitis of the ulna with extension to the elbow joint. Urine culture—staphylococcus albus. Treatment begun on the third day. The disease evolved uneventfully and rapidly and resolved completely. Total dosage of penicillin—200,000 units.

Case 11—M. J., aged eight months. Acute osteomyelitis of the humerus with extension to the shoulder. Admitted twenty-three days after the onset. High pyrexia. Blood culture negative. Penicillin treatment was not begun until the forty-third day. Progress was not satisfactory and three weeks later there was dehydration, and marked emaciation, with vomiting. Pyrexia remained high and the child died. Autopsy—fatty degeneration of the liver. Total dosage of penicillin—2,500,000 units.

Case 12—L. D., aged eight months. Acute osteomyelitis of the humerus with involvement of the elbow. Fulminating illness with high pyrexia. Gross swelling of the upper arm and abscess over the lower end of the humerus. Abscess aspirated. Culture—staphylococcus aureus. Penicillin treatment begun twelve hours after admission, both by intramuscular injection and intravenously. Child died three hours later. Total dosage of penicillin—200,000 units.

Case 13—L. R., aged two years. Acute osteomyelitis upper end of femur, involving hip joint. Blood culture negative. No suppuration. Penicillin begun on the sixteenth day. Satisfactory resolution. No marked radiographic changes. Total dosage of penicillin—1,000,000 units.

Case 14—C. C., aged two years. Subacute osteomyelitis of femur involving hip joint. Leucocytosis 41,000. Blood culture negative. Periosteal reaction seen radiographically. Penicillin treatment begun on the sixth day. Progress was satisfactory but patient left hospital before completion of treatment. Total dosage of penicillin—300,000 units.

Case 15—T. N., aged five weeks. Subacute osteomyelitis of femur involving hip joint. General condition poor. Abscess formed. Incision. Penicillin treatment begun on twelfth day. Condition gradually became worse. Severe dehydration. Further abscesses formed, incised. Culture—staphylococcus albus. Child became unconscious and died forty-five days after the onset. Total dosage of penicillin—3,100,000 units.

Case 16—B. R., aged seven weeks. Acute osteomyelitis of femur. High pyrexia. Metastatic abscesses at elbow and over sterno-clavicular joint. Incised. Leucocytosis 13,600. Blood culture negative. Pus culture—staphylococcus aureus. Penicillin treatment begun second week. Later, a further abscess developed at the knee and was incised. Radiographs showed severe changes in the femur. Child was discharged with all wounds healed after five months' treatment. Total dosage of penicillin—3,600,000 units.

Case 17—L. I., aged sixteen months. Multiple bone lesions (femur, humerus, radius). Multiple abscesses were incised and chronic sinuses developed. Culture of pus yielded staphylococcus aureus. General condition remained good despite the suppuration and severe bone changes in all the affected bones. Repeated courses of penicillin were given. After twenty-nine months' treatment all sinuses were healed and the child was discharged. Total dosage of penicillin—4,950,000 units.

DISCUSSION

Analysis of these seventeen cases (Table I) shows that in six cases there were no clinically evident suppuration and no significant radiographic changes in the bone; six patients had both suppuration and bone changes; three had suppuration without bone changes; and two had bone changes without suppuration. Thus, despite the use of penicillin the incidence of suppuration and bone changes was high. It is of interest to note that two of the three patients who died had no clinically evident suppuration and no marked radiographic changes. Only one of the seventeen patients developed multiple bone lesions. This low incidence can reasonably be attributed to the favourable influence of penicillin, for the incidence of multiple bone lesions in patients treated by other methods was much higher—23 per cent in our series of forty-eight cases.

The main clinical features and the results in the control group of forty-eight cases are shown in Table II; and the results in the penicillin-treated group and the control group are

tabulated together in Table III. Comparison of the two groups suggests the following conclusions:

1) The use of penicillin did not lead to improvement in the end-results as compared with those obtained by other methods.

2) Penicillin reduced: *a*) the number of cases with multiple bone lesions; *b*) the incidence of abscess formation; and *c*) the average time of healing.

3) The development of bone changes as seen radiographically was not prevented by penicillin nor was the evolution of the changes altered.

4) The average percentage of cases that resolved was approximately the same with and without penicillin.

TABLE III

SUMMARY OF RESULTS WITH AND WITHOUT PENICILLIN

Treatment	Cases	Quiescent		Slight activity		Deaths	
Penicillin	17	11	64%	3	18%	3	18%
Old methods	48	31	64%	13	27%	4	9%

We fully realise that in this series penicillin treatment was in most cases begun much later in the course of the disease than is desirable. Delay was inevitable because most of the patients were not brought to the hospital immediately after the onset of the disease. Thus in only one case was it possible to begin the administration of penicillin within the first forty-eight hours of the onset of symptoms. In most cases the interval was from three to eight days. Further research will be required to determine whether the delayed commencement of penicillin therapy was the significant factor in the disappointing results obtained, or whether osteomyelitis is, in fact, less responsive to penicillin in infants than in older patients. However, the important fact which emerges from this study, and which we wish to emphasize, is that penicillin alone is not the final answer to the problem of acute osteomyelitis. The disease is still able, on occasions—as Professor Leveuf believed—to run the typical course which it was wont to do before the introduction of penicillin therapy. The fulminating cases, the fatal cases, the cases with gross destruction of bone—all can still occur. Penicillin may help the body to resist the disease, but it does not itself bring about the cure of osteomyelitis.

SUMMARY

1. The clinical findings and results in seventeen patients under two years of age, suffering from acute osteomyelitis, have been studied and compared with forty-eight similar cases treated without penicillin.

2. The results in the penicillin-treated group were not greatly superior to those in the control group and did not justify the high hopes that have been entertained for penicillin as a certain cure for osteomyelitis.

This investigation was undertaken in Paris at the suggestion of my friend and teacher the late Professor Jacques Leveuf, to whose memory and work I wish to pay tribute.

REFERENCES

BODIAN, M. (1945): Proceedings of the Royal Society of Medicine (Section for the Study of Disease in Children), **38**, 572.

LEVEUF, J. (1946): Personal communication.

MCADAM, I. W. J. (1945): British Journal of Surgery, **33**, 167.

OSTEOCHONDROMATOSIS OF THE HIP JOINT

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Osteochondromatosis of the hip joint is uncommon. The available literature published since 1900 has shown a total of 187 cases of osteochondromatosis of all joints, among which there were only twenty-two instances of involvement of the hip. The largest series is reported by Mussey and Henderson (1949), who found five examples of osteochondromatosis of the hip in a total of 105 osteochondromatoses of all joints operated on at the Mayo Clinic between 1910 and 1945. The purpose of this paper is to describe three further cases with hip joint involvement, to discuss the radiological features of the disease and to illustrate the diagnostic value of arthrography.

One patient in whom both shoulder joints were affected and another with osteochondromatosis of the knee are mentioned in this paper. The distribution of these cases and the 187 recorded in the literature is shown in Table I.

TABLE I

DISTRIBUTION OF THE LESIONS IN 191 CASES OF OSTEOCHONDROMATOSIS

Joint	*Bilateral*	*Unilateral*	*Total*
Knee	11	99	110
Elbow	3	33	36
Hip	2	23	25
Shoulder	1	9	10
Ankle	—	5	5
Carpus	—	2	2
Tarsus	—	1	1
Finger	—	2	2
Total	17	174	191

CASE REPORTS

Case 1—T. M., a man aged twenty-five years, was first seen in April 1940. He complained that for eight years he had had attacks of pain in the right hip radiating to the knee. Examination of the hip showed 30 degrees of flexion deformity, 60 degrees of flexion movement, and absence of all other movements. There was tenderness around the joint. Radiographs showed a large mass of opacities below the acetabulum, with erosion of the acetabulum and the head of the femur. The appearances were those of synovial osteochondromatosis. At operation, undertaken by Mr Philip Wiles in May 1940, about eighty loose bodies were removed.

Case 2 (Figs. 1 to 3)—R. W., a young man aged eighteen years, was first seen in May 1946. He complained of pain in the left hip, intermittent for many years and continuous for the past eighteen months; it was worse after exertion. There was slight limitation of movement of the left hip in all directions. Radiographic examination showed many small round opaque bodies in the joint. There were marked defects at the junction of the femoral head and neck causing the neck to appear somewhat conical in shape. Operation was performed by Mr Philip Wiles. Sixty-one

FIG. 1

FIG. 2

Case 2. Figure 1—Osteochondromatosis of the hip joint. Note the conical appearance of the femoral neck, erosion of bone at the cervico-capital junction, and multiple opaque loose bodies. Figure 2—Tracings of comparable radiographs, to show filling in of the bone erosions after removal of the loose bodies. Continuous line: outline before operation. Broken line: outline three years after operation.

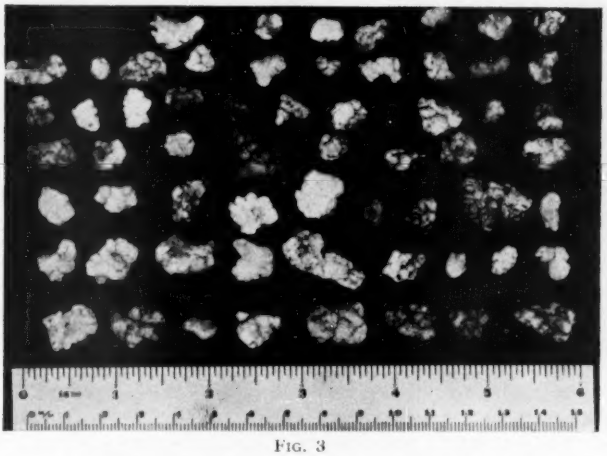

FIG. 3

Case 2—Sixty-one osteochondromata removed from the hip.

osteochondromata were removed from the joint. The synovial membrane was found thickened and some of the bodies were embedded in it. Convalescence was uneventful. Three years after operation the clinical condition was satisfactory, and there were no symptoms; radiographs showed that bone deposited at the cervico-capital junction was making the defects in the femur appear shallower.

Case 3 (Figs. 4 to 6)—G. W., a woman aged thirty-three years, was first seen in November 1948. She complained that for six years she had had pain and stiffness in the left hip, the pain radiating to the left knee. Examination of the left hip revealed slight flexion deformity and moderate

FIG. 4

FIG. 5

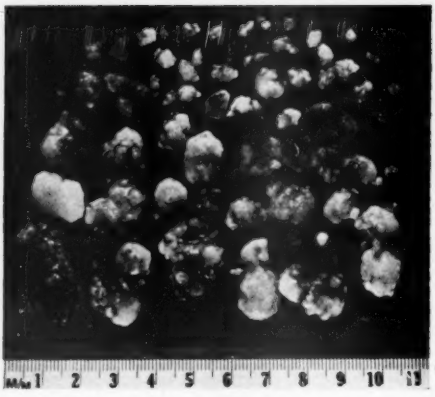

FIG. 6

Case 3. Figure 4—Osteochondromatosis of the left hip joint. Note the erosion of bone at the junction of the head and neck of the femur. A single opaque body is visible just above the lesser trochanter. The normal right hip is shown for comparison. Figure 5—Arthrogram. Loose bodies are well shown. They lie mainly around the femoral neck and cervico-capital junction. Figure 6—Sixty-two osteochondromata removed from the hip joint.

restriction of all movements, forcing of further movement being limited by pain and spasm. A radiograph showed a faint opacity on the medial side of the base of the femoral neck. Defects were present at the cervico-capital junction, and the neck tended to assume a conical shape. There was slight narrowing of the joint. A tentative diagnosis of osteochondromatosis was made because the defects in a somewhat conical femoral neck and the small intracapsular opacity appeared, in the light of our previous experience, to be significant. Ten months later there was

no marked change in the physical signs and radiological appearances but the symptoms were sufficiently disabling to demand operative treatment. Before operation, an arthrogram was obtained after injection of diodone (35 per cent solution) into the hip joint. This showed numerous intracapsular translucent bodies. The small opacity seen on the plain radiograph was shown to be in the centre of a large translucent body.

At operation sixty-two osteochondromata were removed from the joint. Many of them were loose, but some were embedded in the synovial membrane which was moderately thickened. The bodies varied greatly in size, the largest being one inch long and half an inch across, and the smallest about one-tenth of an inch in diameter. They were composed mainly of cartilage but radiographs of the larger specimens showed a few areas of calcification.

DISCUSSION

Radiographs in two of these three cases showed defects at the cervico-capital junction and a femoral neck of a rather conical shape. Case 1 showed erosions of both the acetabulum and of the head of the femur. The radiographic changes were most marked in Case 2. The arthrogram in Case 3 showed that several of the osteochondromata lay in defects at the junction of head and neck and formed a corona there. The findings suggested that the loose bodies had caused pressure-resorption of bone in this region. This hypothesis is supported

FIG. 7 FIG. 8 FIG. 9

Bilateral osteochondromatosis of the shoulder joint. Figure 7—Left shoulder, 1940. Many loose bodies are present. Note erosion of the neck of the humerus. Figure 8—Condition of left shoulder ten years after removal of loose bodies. There is well-marked osteoarthritic lipping, but no opaque loose bodies are visible. The erosion of the neck of the humerus is no longer seen. Figure 9—Right shoulder, 1950. Opaque loose bodies and osteoarthritic lipping can be seen.

by the radiograph taken three years after operation in Case 2, which shows the defects to be partly filled by the deposition of new bone. A similar filling-in of bone erosions after operation was observed in a patient with osteochondromatosis of the shoulder joint (see below). The site of the erosions in the hip joint is probably determined by the characteristic distribution of the cartilaginous bodies at the synovial-cartilaginous junction (Wilmoth 1941).

Radiographic appearances similar to those described above have been reported by Brailsford (1948), who also found that further growth had occurred inside the capsule, and the lesion in the femoral neck appeared to have resolved within a year of operation for osteochondromatosis of the hip. Indentation of the femoral neck by osteochondromata was also recorded by Fairbank (1950). The radiographs published by other authors have been examined and there appear to be similar erosions in one of the cases recorded by Kartal (1930). An erosion may also be present in the case reported by Lieberman (1936). However, this feature is not mentioned by either of these authors. Erosion of the neck of the femur was noted by Freund (1937). Of the remaining seventeen cases in the literature, radiographs were not published in eight, and in seven they are not clear enough to permit a definite

opinion as to the presence of bone erosion. In two cases there were no erosions visible in the antero-posterior views.

Erosion of bone by osteochondromata of the knee has been recorded by Lexer (1907) and by Kienböck (1916–17); and in the shoulder by Hagemann (1913) and by Curr (1949). In some instances the bodies have eroded through the capsule and been found lying outside the joint. We have also seen erosions of the humerus in a female patient aged thirty-one years, first seen in June 1940, suffering from osteochondromatosis of the left shoulder; many loose bodies were removed (Fig. 7). Ten years later a radiograph showed osteoarthritic lipping of the inferior articular margin of the humerus and glenoid (Fig. 8). The erosion seen previously was no longer visible and there were no opaque loose bodies. Radiographs of the right shoulder showed five opaque loose bodies lying in the medial part of the joint (Fig. 9), and osteoarthritic lipping of the lower articular margins of the humerus and glenoid: no erosions were visible.

In a typical case the radiological diagnosis of osteochondromatosis presents no difficulty. But when there are no opaque loose bodies—as in cases recorded by Jones (1927), Freund (1937) and Fairbank (1950)—or when there are only one or two opaque bodies—as in our Case 3—arthrography is a valuable aid to diagnosis. It should assist in the differentiation of this condition from loose-body formation due to other causes such as osteochondritis dissecans. Moreover it will demonstrate the full extent of the lesion when only a few of the bodies are radio-opaque. We have recently seen a patient with osteochondromatosis of the knee joint in which there were multiple small opaque bodies posteriorly and anteriorly below the patella. The arthrogram revealed multiple translucent bodies in the suprapatellar pouch.

SUMMARY

1. Three cases of osteochondromatosis of the hip joint are described.
2. Attention is drawn to the diagnostic importance of erosions at the junction of head and neck of the femur, and the conical shape of the femoral neck.
3. Arthrography is of particular value in diagnosis when the loose bodies are radio-translucent.

We wish to express our grateful thanks to Mr Philip Wiles for his kind help and advice in the preparation of this paper.

REFERENCES

BRAILSFORD, J. F. (1948): The Radiology of Bones and Joints. Fourth edition. London: J. and A. Churchill Ltd., 308, 128.
CURR, J. F. (1949): British Medical Journal, **ii**, 1020.
FAIRBANK, H. A. T. (1950): Proceedings of the Royal Society of Medicine (Section of Orthopaedics), **43**, 113.
FREUND, E. (1937): Archives of Surgery, **34**, 670.
HAGEMANN, R. (1913): Medizinische Klinik, **9**, 1243.
JONES, H. T. (1927): Journal of Bone and Joint Surgery, **9**, 310.
KARTAL, ST (1930): Surgery, Gynecology and Obstetrics, **51**, 99.
KIENBÖCK, R. (1916–17): Fortschritte auf dem Gebiete der Röntgenstrahlen, **24**, 468.
LEXER, E. (1907): Deutsche Zeitschrift für Chirurgie, **88**, 311.
LIEBERMAN, C. A. (1936): quoted in Year Book of Radiology 1937, 63.
MUSSEY, R. D., and HENDERSON, M. S. (1949): Journal of Bone and Joint Surgery, **31–A**, 619.
WILMOTH, C. L. (1941): Journal of Bone and Joint Surgery, **23**, 367.

OSTEOCHONDROMATOSIS OF THE HIP JOINT

Report of a Case

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This report is submitted because the patient concerned illustrates rather unusual stages in the development of osteochondromatosis of the hip joint, itself an uncommon condition.

A railway worker, twenty years old, was struck heavily in the right buttock on December 25, 1945. About a month later he began to complain of continuous and increasing pain in the right hip. He attended hospital eight months after the injury. On examination there was limitation of hip movements, which were painful, and radiographs showed a defect in the lower part of the head of the femur with a rather faint shadow resembling that of a loose body in the region of the upper part of the base of the femoral neck (Fig. 1). The hip

FIG. 1

Radiographs of the hip joints seven months after the onset of symptoms. Note, in the right hip, the defect in the lower part of the head of the femur, and the faint shadows at the lower margin of the joint and near the upper border of the femoral neck.

was immobilised in plaster-of-Paris for four months. A second radiograph taken after removal of the plaster showed the loose body rather more clearly outlined in a hip showing disuse atrophy (Fig. 2), but a third film three months later showed massive deposition of opaque " loose " bodies to a quite unexpected degree (Fig. 3).

The hip was explored fifteen months after the onset of symptoms. The " tumour " mass was adherent to the neck of the femur and to the capsule, and had to be gouged away. Complete removal was impossible. The naked-eye appearances are illustrated in Figure 4. The pathological appearances were those of a chondroma.

The patient was last seen three years after the operation. Radiographs (Fig. 5) then showed persisting radio-opaque bodies in the hip, but no massive recurrence and no marked erosion of bone.

FIG. 2

FIG. 3

Figure 2—Four months later. There is faint opaque mottling throughout the area of the hip joint and capsule. Figure 3—Three months later. There is striking increase in calcification of the intracapsular mass.

FIG. 4

FIG. 5

Figure 4—Photograph of the osteochondromatous mass removed at operation. Figure 5—Radiograph three years after operation. Irregular opacities are still present but there has been no massive recurrence and no further resorption of bone.

COMMENT

The remarkable change in the radiographic appearances in the three-month interval between the second and third radiographs (Figs. 2 and 3) must be taken to indicate rapid extension of the disease. It was, in fact, so rapid that suspicions of malignancy were raised at the time. But the subsequent history and the result three years later support the suggestion that the condition was simply an osteochondromatosis, with an unusual "explosive" phase in its development.

INTRATHORACIC MENINGOCELE, SPINAL DEFORMITY, AND MULTIPLE NEUROFIBROMATOSIS

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Multiple neurofibromatosis, originally described by von Recklinghausen (1882) as a disease of the cutaneous nerves, is now recognised to have many pathological manifestations. Its presenting symptoms are protean and often bizarre. In the past twenty years an enormous literature has accumulated which deals with various aspects of the disease, new manifestations and recently discovered associated pathological changes. Much of this information is relevant to orthopaedic surgery in that it concerns the skeletal changes seen in patients with multiple neurofibromatosis.

In an extensive review Preiser and Davenport (1918) stated that von Recklinghausen's disease occurs in about one in two hundred of the general population, and affects both sexes equally in all races and at all ages. Approximately one case in ten shows skeletal changes, and in one half of these the spine is involved. There is a remarkable association of this involvement of the spine with the very uncommon condition of lateral intrathoracic meningocele. In a review of the literature to the end of 1949, reports of only five such cases were found. Two further cases are reported here.

CASE REPORTS

Case 1—A woman aged twenty-three years, first seen in 1948 at St Mary's Hospital, London. She complained of steadily increasing pain between the shoulder-blades during eight years. Eighteen months previously she had been examined radiographically at another hospital, and told that she was suffering from an old crush fracture of a dorsal vertebra. Twelve months' physiotherapy gave no relief. The pain was localised to a small area between the shoulder blades and occasionally radiated round the left side of her chest. It was aggravated by forced movements of the spine, particularly on twisting to the left. She had also noticed that she was becoming round shouldered, but her general health had remained excellent. *On clinical examination* several large and irregular café-au-lait patches were seen on her trunk and buttocks. She had a slight upper dorsal kyphosis but no obvious scoliosis. There was no limitation of spinal movement. Examination of the central nervous system revealed no abnormality apart from defective posterior column conduction as shown by loss of vibration sensibility in the legs and loss of postural sensibility in both great toes. No other physical abnormality was detected clinically. *Radiographic examination* of the spine (Figs. 1 and 2) showed disappearance of the pedicles of the fifth, sixth and seventh thoracic vertebrae on the left side, and spreading of the vertebral ends of the left sixth, seventh and eighth ribs, with erosion of their related margins. There was well-marked scalloping of the posterior aspect of the fifth, sixth, seventh and eighth thoracic vertebral bodies, but the intervening disc spaces were relatively unaffected. There was wedging of the affected vertebrae, giving rise to a rounded kypho-scoliosis. A radiograph of the chest (Fig. 3) showed a soft-tissue tumour in relation to the 5–6 intercostal space. *Lumbar puncture*—The cerebrospinal fluid pressure was 120 millimetres; no block was demonstrated. Chemical analysis of the fluid was normal; protein was 20 milligrams per cent.

In spite of the normal cerebrospinal fluid protein content, a diagnosis of "dumb-bell" neurofibroma was made with some confidence on the basis of the radiographic appearances and the pigmented skin lesions typical of von Recklinghausen's disease.

Operation (Mr A. Dickson Wright)—After costo-transversectomy (left fifth and sixth ribs) a soft-tissue tumour was immediately displayed (Fig. 4). It lay outside the pleura and emerged through a defect in the region of the pedicles of the sixth and seventh thoracic vertebrae. The tumour was

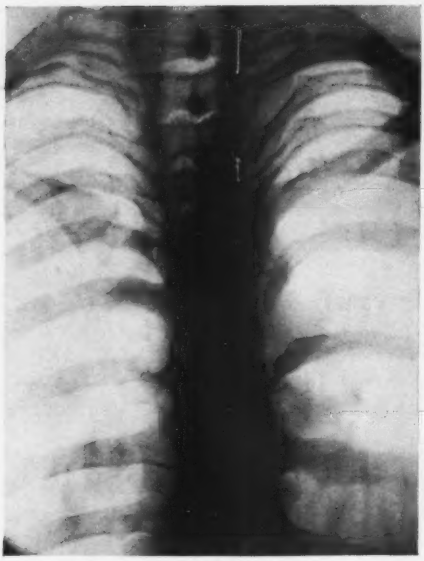

FIG. 1

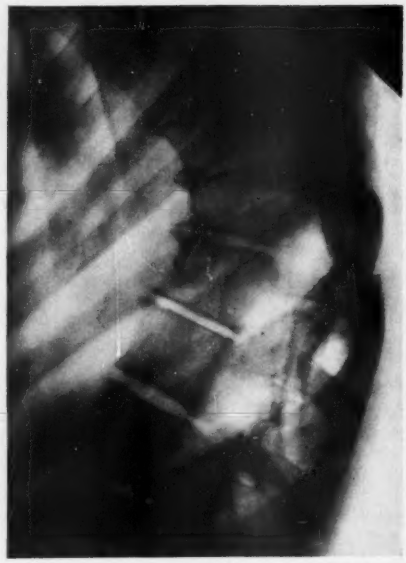

FIG. 2

Case 1—Radiographs of the thoracic spine showing, in the antero-posterior view (Fig. 1), marked spreading of the sixth, seventh and eighth ribs, the margins of which are eroded. Note in the lateral view (Fig. 2) the disappearance of the pedicles of the fifth, sixth and seventh thoracic vertebrae, the scalloping of the posterior margins of four vertebral bodies (but not the intervening disc spaces), and the anterior wedging of the affected vertebrae.

FIG. 3

Case 1—Chest showing soft tissue opacity in relation to the fifth-sixth intercostal space.

gently pulsatile and collapsible on pressure; its wall resembled dura mater in colour and texture. After incision of the sac, the spinal cord was seen lying in its normal position in no way embarrassed or distorted by the dural herniation. The meningocele was readily excised and the resultant dural opening closed by silk sutures. The patient made an uninterrupted recovery from the operation and was discharged wearing a plaster jacket. Eighteen months later she was free from pain. She is to be readmitted for operative fusion of the mechanically unsound segment of her dorsal spine.

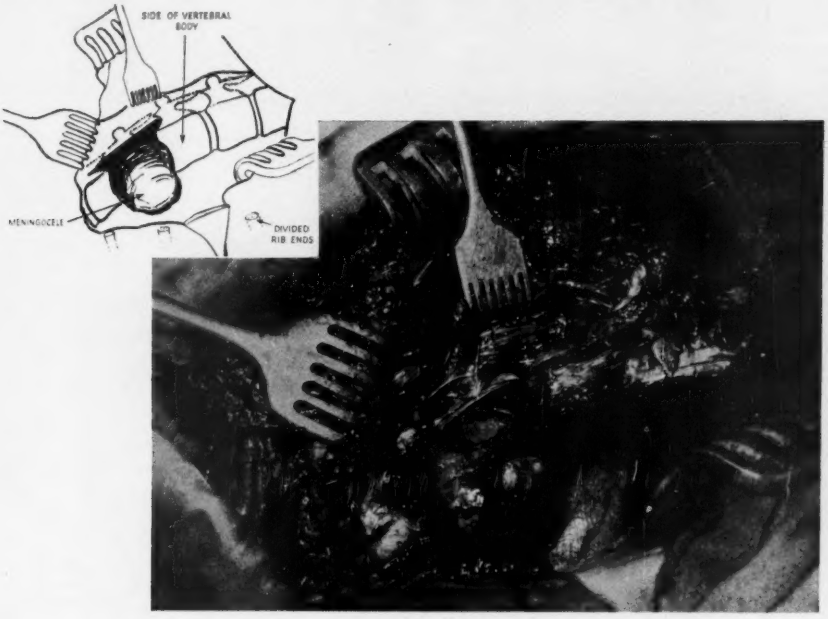

FIG. 4
Case 1—The meningocele exposed at operation.

Case 2—An alert little girl, first attending the Royal National Orthopaedic Hospital in 1949 at the age of eight and a half years, because of her inability to walk and an increasing curvature of the spine. At three years old she had attended a clinic where she was noted as having a mid-dorsal scoliosis and multiple neurofibromatosis. Her walking was said to be normal at that time, and she had been given a spinal support. Four years later the scoliosis became worse after a fall, and her left leg became spastic. The spasticity improved after head traction in a plaster bed. She continued to wear a spinal support on her discharge from hospital but in the months before the latest examination both legs became so spastic that she was unable to get about.

Examination—The skin of the trunk and thighs was covered with lesions typical of neurofibromatosis. There was an acutely angulated kypho-scoliosis convex to the right, the apex at the sixth thoracic vertebra, with compensatory curves above and below (Fig.5). Examination of the central nervous system showed a severe spastic paraplegia and impairment of cutaneous sensibility to light touch and pin-prick below the dermatomes corresponding to the level of T.12. Radiographs of the spine (Figs. 6 and 7) showed gross lateral displacement of the seventh and eighth thoracic vertebrae, which formed the apex of an acute kypho-scoliosis. The 7–8 intercostal space was increased in width and the related margins of the ribs were eroded. The posterior surfaces of the vertebral bodies at the level of the deformity showed well-marked scalloping. The appearances suggested localised bone resorption from the pressure of a tumour mass. *Lumbar puncture*—Cerebrospinal fluid pressure, 275 millimetres. Free rise and fall on jugular compression. Cerebrospinal fluid chemical analysis, normal; protein, 20 milligrams per cent. *Myelography* showed an obstruction at the level of the eleventh thoracic vertebra, but the examination was technically

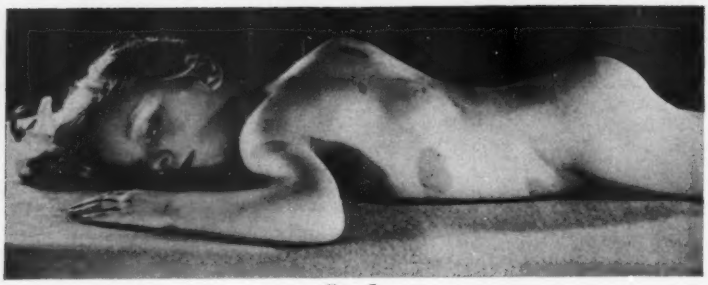

FIG. 5

Case 2—Photograph of the child. Note the gross kyphosis, the areas of pigmentation, and the soft tissue swelling over the left lower ribs.

FIG. 6

Case 2—Thoracic spine showing severe kypho-scoliosis. Note in the antero-posterior view the gross lateral displacement of the seventh and eighth thoracic vertebrae, and the increased width of the seventh-eighth intercostal space.

FIG. 7

Case 2—The lateral view shows well marked scalloping of the posterior margins of four vertebral bodies.

unsatisfactory and no other useful information was obtained. (Post-operative myelography demonstrated the meningocele more clearly and showed that the dilatation of the subarachnoid space extended over several segments corresponding to the erosion of the vertebral bodies.) Operation was advised for relief of the paraplegia which was presumed to be due to an incomplete obstruction caused by the distorted vertebral column.

Operation (Mr H. J. Seddon)—Antero-lateral exposure of the spinal cord in the concavity of the scoliosis showed it to be stretched over a sharp bony mass. The cord was feebly pulsatile across the site of obstruction and this pulsation improved when the offending ledge of bone was removed. Exploration at the convexity of the scoliosis revealed a sessile intrathoracic and extra-pleural meningocele, approximately 3 centimetres long by 2·5 centimetres broad, which was readily exposed by removing the medial ends of the three related ribs (Fig. 8). No attempt was made to remove the sac because the spinal cord was apparently in no way embarrassed by it. A mass of tissue at the site of an intercostal nerve was removed for examination and proved to be a plexiform neuroma. Post-operative progress was uneventful. There was an initial improvement of the paraplegia as manifested by reduction in the spasticity of the legs, but this early promise was not fulfilled and she remained with severe paralysis three months later.

Comment—This case is of interest not only as an example of lateral intrathoracic meningocele; it also demonstrates the compression paraplegia which not uncommonly complicates gross kypho-scoliosis in von Recklinghausen's disease.

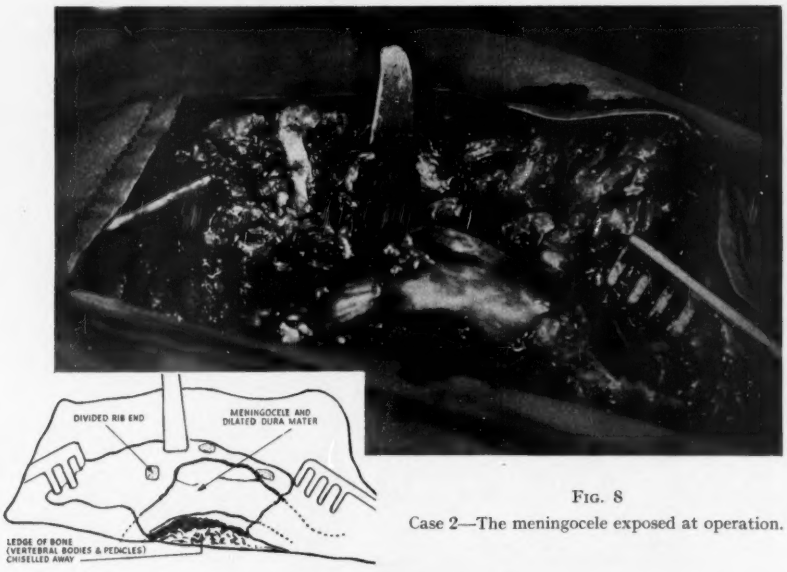

FIG. 8
Case 2—The meningocele exposed at operation.

DISCUSSION

Reports of eight cases of lateral intrathoracic meningocele have been found in the literature. Two more are reported here, making a total of ten in all, of which at least seven occurred in association with multiple neurofibromatosis. Such an association is unlikely to be fortuitous and may help to shed some light on the more common occurrence of spinal deformity in this disease. The deformity has been variously attributed to the action of periosteal neurofibromata (Brooks 1924) or an ill-defined osteomalacia (Gould 1918), but the evidence is inconclusive. Cross (1949) was of the opinion that the meningocele is due to a diseased dura and not primarily to a defect in the bone. The drawing of Ameuille's (1940) specimen, which is reproduced in Figure 9, lends support to this view. The gross dilatation and sacculation of the spinal dura in his case of lateral meningocele is very striking.

FIG. 9

Extensive dilatation and sacculation of the spinal dura in a case of lateral meningocele. (From Ameuille *et al.*, reproduced by permission of the authors.)

My attention has been drawn by a personal communication (Bull 1950) to a case of a woman, aged thirty-seven years, who exhibited the cutaneous lesions of neurofibromatosis and who died of a cerebral tumour (spongioblastoma multiforme). The radiographs of her lumbar spine (Figs. 10 and 11) showed the same scalloping of the posterior surfaces of several vertebral bodies that is seen in cases of lateral meningocele; and the transverse processes were eroded. Post-mortem examination of the spine showed that the vertebral bodies from the twelfth thoracic to the third lumbar (inclusive) were grossly deformed and apparently hollowed out from behind by the distended theca which bulged through the large intervertebral foraminae.

One is tempted to put forward the hypothesis that in von Recklinghausen's disease the spinal deformity may be due to the prolonged aneurysmal action of an undisclosed meningocele or of an intrathecal dilatation of the dura mater. Further study is needed to determine how commonly the spinal dura is affected in cases of multiple neurofibromatosis with deformity of the spine. At present we can go no further than to say that a lateral intrathoracic extrapleural meningocele associated with spinal deformity in von Recklinghausen's disease constitutes a definite clinical entity whose specific features have been evident in the case reports so

FIG. 10

FIG. 11

Erosion of the left upper lumbar transverse processes (Fig. 10) and scalloping of vertebral bodies (Fig. 11) in a patient with distension of the spinal theca associated with cerebral tumour.

regularly that we might now reasonably expect to be able to make a correct pre-operative diagnosis.

SUMMARY

Two cases of lateral meningocele and spinal deformity in von Recklinghausen's disease are reported. Of the ten known cases of lateral meningocele, seven have occurred in patients with neurofibromatosis. The relation of spinal deformity and neurofibromatosis is briefly discussed.

I am indebted to Mr H. J. Seddon for his assistance in the preparation of this paper and for permission to publish Case 2, to Mr V. H. Ellis and Mr A. Dickson Wright for permission to publish Case 1, and to Mr W. McKissock for the case whose radiographs are shown in Figures 10 and 11.

REFERENCES

AMEUILLE, P., WILMOTH, P., and KUDELSKI, CH. (1940): Méningocèle rachidienne à développement intrapleural. Bulletins et Mémoires de la Société médicale des Hôpitaux de Paris, **56,** 608.

BROOKS, B., and LEHMAN, E. P. (1924): Bone changes in Recklinghausen's neurofibromatosis. Surgery, Gynecology and Obstetrics, **38,** 587.

BULL, JAMES (1950): Personal communication.

CROSS, G. O., REAVIS, J. R., and SAUNDERS, W. W. (1949): Lateral intrathoracic meningocele. Journal of Neurosurgery, **6,** 423.

GOULD, E. P. (1918): The bone changes occurring in von Recklinghausen's disease. Quarterly Journal of Medicine, **11,** 221.

MILLER, A. (1936): Neurofibromatosis with reference to skeletal changes, compression myelitis and malignant degeneration. Archives of Surgery, **32,** 109.

MOORE, B. H. (1941): Some orthopaedic relationships of neurofibromatosis. Journal of Bone and Joint Surgery, **23,** 109.

POHL, R. (1933): Meningokele im Brustraum unter dem Bilde eines intrathorakalen Rundschattens. Röntgen-Praxis, **5,** 747.

PREISER, S. A., and DAVENPORT, C. B. (1918): Multiple neurofibromatosis (von Recklinghausen's disease) and its inheritance: with description of a case. American Journal of the Medical Sciences, **156,** 507.

RECKLINGHAUSEN, F. VON (1882): Über die multiplen Fibrome der Haut und ihre Beziehung zu den multiplen Neuromen. Berlin: Hirschwald.

SCHÜLLER, A., and ÜIBERALL, H. (1938): A case of neurofibromatosis Recklinghausen combined with lateral spinal meningocele. Confinia Neurologica, **1,** 312.

SENGPIEL, G. W., RUZICKA, F. F., and LODMELL, E. A. (1948): Lateral intrathoracic meningocele. Radiology, **50,** 515.

UHLMANN, E., and GROSSMAN, A. (1940): Von Recklinghausen's neurofibromatosis with bone manifestations. Annals of Internal Medicine, **14,** 225.

WEBER, F. PARKES (1930): Periosteal neurofibromatosis, with a short consideration of the whole subject of neurofibromatosis. Quarterly Journal of Medicine, **23,** 151.

WELCH, C. S., ETTINGER, A., and HECHT, P. L. (1948): Recklinghausen's neurofibromatosis associated with intrathoracic meningocele: report of case. New England Journal of Medicine, **238,** 622.

THE CAUSATIVE MECHANISM IN MORTON'S METATARSALGIA

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Several articles in the orthopaedic literature of recent years have dealt with the etiology of Morton's metatarsalgia. It has been made sufficiently clear that a neuroma of one of the plantar digital nerves is a constant finding in this condition, and that the removal of the neuroma affords a radical cure (Betts 1940, McElvenny 1943). But the origin of the neuroma is not made clear from these reports, nor is there an explanation of those sudden sharp pains which make Morton's metatarsalgia such a crippling—though innocent—disease. For these reasons it seems worth while to draw attention to two observations which can be easily made in every case of Morton's disease.

First observation: a diagnostic clinical test—The patient's foot is clasped around the metatarsal heads with the fingers of the left hand while the thumb of the right hand exerts firm pressure on the sole of the foot at the site of the suspected neuroma, usually between the third and fourth metatarsal heads. On alternating pressure with the fingers of the left and thumb of

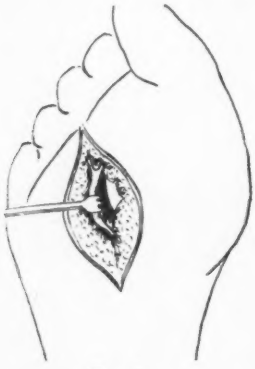

FIG. 1

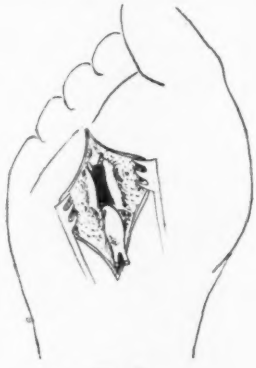

FIG. 2

Figure 1—The neuroma has been mobilised and drawn aside. It appears to form the plantar wall of the intermetatarsal bursa. The bursa has been opened, and is seen on the medial side of the tumour. Medial to the bursa the capsule covering the third metatarsal head is partly visible. Figure 2—The distal connections of the neuroma have been cut, allowing it to be turned proximally. The cleft between the metatarsal heads is clearly seen. Note that the plantar nerve should be divided at least 1 centimetre from the intermetatarsal bursa, to avoid the formation of a painful neuroma in the weight-bearing part of the sole. In one of our patients such a neuroma had to be removed at a second operation.

the right hand, there can be felt a small mass which is pressed in between the two metatarsal heads by the thumb and pushed back into the sole of the foot by lateral compression of the metatarsal heads with the fingers. If this compression is done with some force, the mass may be pinched for a moment between the metatarsal heads before it is pushed out. In the case in which this mass contains or is formed by a neuroma, the characteristic pain coincides with a palpable click caused by the tumour escaping into the sole of the foot. The objective sign—the click—is found many times more frequently than the subjective sign—the sudden pain in the toes. Indeed, many feet with unstable and splayed metatarsals give a more or

less distinct sensation of pinching of soft tissue upon lateral compression of the metatarsal heads. In these weak feet the widening of the intermetatarsal spaces upon weight-bearing allows displacement of tissue from the sole of the foot into those spaces. The metatarsal heads are normally separated by a small bursa. Repeated separation and approximation of the metatarsal heads lead to enlargement of this bursa and to displacement of plantar tissue into the space occupied by the bursa.

Second observation—At operation, when the neuroma is laid bare by a longitudinal incision in the sole between the metatarsal heads it can be easily pushed into the intermetatarsal space and is seen to be pinched and afterwards pressed out upon lateral compression of the metatarsal heads by the surgeon's hand. This is accompanied by the same click that has been mentioned above. If the neuroma is carefully removed by gentle dissection it will be found to be adherent to the intermetatarsal bursa and, indeed, to be so intimately connected with the plantar wall of the bursa that it cannot be removed without opening the bursa (Figs. 1 and 2).

If the bursa is inspected after removal of the neuroma it will appear to be enlarged and to bear the marks of frequent damage to its fibrous walls in the form of thickening and formation of irregular fibrous bands and layers.

The foregoing observations suggest that the neuroma is caused mechanically by repeated pinching of the plantar nerve between the metatarsal heads during the abnormal movements associated with weak transverse arches. According to Nissen's (1948) observations, the plantar digital artery may also be caught and thereby included in the tumour.

Our observations are based on operative findings in twelve consecutive cases of Morton's disease.

DISCUSSION

Morton (1876) suggested that pinching of the plantar nerve between the fourth and fifth metatarsal heads might be the cause of the pain. Later publications have, for the most part, obscured rather than cleared our vision. Even Nissen's excellent and extensive study contributed somewhat to the confusion, because he suggested that the changes in the nerve might be due to ischaemia and that they pointed to a primary arterial degeneration. "So far," he added, "no reason has been found why the digital vessels of the 3–4 interspace are particularly subject to degeneration." The writer of the present article returns to Morton's original opinion, with the qualification—in agreement with most authors—that it is not the 4–5 but the 3–4, and sometimes the 2–3, interspace where the pinching takes place. Abnormal mobility of the metatarsals, giving rise to widening of the bursa between their heads, creates a space into which plantar tissue, including the plantar nerves and vessels, may enter, to be pinched by subsequent movements of the metatarsal heads. Repeated trauma produces swelling and fibrous reaction in and around the nerve and leads to tumour formation.

SUMMARY

1. A clinical test of diagnostic significance in Morton's metatarsalgia is described.
2. Findings at operation in twelve cases are recorded.
3. The causation of the digital neuroma is discussed.

REFERENCES

BETTS, L. O. (1940): Medical Journal of Australia, **1, 514**.
MCELVENNY, R. T. (1943): Journal of Bone and Joint Surgery, **25, 675**.
MORTON, T. G. (1876): American Journal of the Medical Sciences, **71, 37**.
NISSEN, K. I. (1948): Journal of Bone and Joint Surgery, **30–B, 84**.
WINKLER, H., FELTNER, J. B., and KIMMELSTIEL, P. (1948): Journal of Bone and Joint Surgery, **30–A, 496**.

DE QUERVAIN'S DISEASE

BRYAN KEON-COHEN, MELBOURNE, AUSTRALIA

In 1897 de Quervain, who was then assistant to Kocher, first described the lesion at the wrist joint which now bears his name: " It appeared that the complaints were due to localised thickening of the tendon sheaths formed by the fibres of the dorsal carpal ligament and that the functional disorder was caused by increased friction at that point." It is extraordinary that half a century later we know little more than he did about the exact nature of the lesion. My interest in this condition was aroused because none of thirteen consecutive patients showed the normal anatomy as it is described in standard works.

ANATOMY OF THE SHORT EXTENSOR TENDONS OF THE THUMB

The extensor retinaculum, a thickening of the deep fascia, bridges the grooves on the dorsal aspects of the lower ends of the radius and ulna, and—being attached by deep processes to the ridges between them—converts them into six osteofibrous canals in which the various extensor tendons are contained. The first canal corresponds with the groove on the outer side of the lower end of the radius and contains the tendons of the abductor pollicis longus and extensor pollicis brevis. The abductor tendon is anterior to the extensor tendon and they are closely applied to one another. The dorsal cutaneous branch of the radial nerve pierces the deep fascia just proximal to the wrist joint. Its three branches, on their way to supply the thumb and radial half of the index finger, pass superficial to the first fibro-osseous canal.

The abductor pollicis longus is inserted into the radial aspect of the base of the first metacarpal bone and a ridge on the trapezium; it commonly gives off a slip to the abductor pollicis brevis. The extensor pollicis brevis is inserted into the dorsal aspect of the base of the proximal phalanx of the thumb. It is a muscle peculiar to Man and unlike the abductor is not generally represented in lower animals. It is truly in its phylogenetic infancy, as its separation from the abductor is complete only in Man and the gorilla. It has a very much smaller tendon than the abductor pollicis longus, a fact scarcely noticed in standard anatomy books. Occasionally it is absent, being represented only by a tendinous ligament passing from the radial styloid to the base of the first phalanx of the thumb.

Variations, especially in the tendon of the abductor pollicis longus, are very common. Forty-six cadavars have been examined in the dissecting room and Dr John Hicks, pathologist at Prince Henry's Hospital, Melbourne, has examined twenty post-mortem subjects, making a total of sixty-six. In fifty-two cases (79 per cent) the abductor pollicis longus was represented by two or more tendons. In sixty-two cases (94 per cent) the tendon of the extensor pollicis brevis was very much the smaller, in eight cases it was present only as a thin wisp of tendon, but in none was it absent. A single fibro-osseous canal is usual, but in twenty-two subjects (33 per cent) the extensor pollicis longus occupied a separate compartment.

The main tendon of abductor pollicis longus is usually cleft. The cleavage may be complete, forming two tendons of equal size; less frequently three or even four tendons are present. It was of interest to find that these divisions were inserted in the following ways: *a*) The divisions united opposite the base of the metacarpal and were inserted in the normal manner. *b*) In thirty cases (45 per cent) the more radial division gave off a slip to the abductor pollicis brevis, and in three cases (4·5 per cent) a slip appeared to pass to the opponens pollicis. The radial division was sometimes inserted directly into the abductor pollicis brevis without any attachment to the trapezium or the metacarpal. *c*) In three instances (4·5 per cent) a small

aberrant tendon was derived from a digastric abductor pollicis longus. Two of these tendons were inserted directly into the abductor pollicis brevis, and the third into the opponens. Such direct insertions should be remembered, for it can be disconcerting when attempting to identify the various tendons at operation to find that traction on one or more of them has no apparent effect on the thumb.

Similar variations from standard anatomical descriptions were noted by Wood in 1867, who found multiple abductor tendons in forty-nine out of seventy-two subjects (68 per cent), with insertions similar to those just described. He did not, however, describe two separate osteofibrous canals. These variations in the abductor tendon may represent a tendency towards further differentiation in the highly specialised human pollex.

Bunnell (1944) reported aberrant tendons in twelve out of twenty-two personal cases of de Quervain's disease. He attempted to differentiate between the lesions present in these twelve cases and the remainder, but found very little difference.

Etiology—No doubt the chief predisposing cause of de Quervain's lesion is crowding of the tendons as they pass over the radial styloid process. Angulation at this level in certain positions of the wrist increases the amount of friction between tendon, tendon sheath and bone. Thus, three lesions arising in women soon after confinement may have been due to continued use of the abducted thumb in holding the baby. In the only bilateral cases in the present series symptoms on the left side were precipitated by excessive use caused by immobilisation of the right wrist after the first operation.

Pathology—The operative findings are constant. The tendon sheath is thickened, sometimes for as much as one and a half inches, the greatest thickening being over the styloid process. Here it may be three to four times the normal thickness of 3 to 4 millimetres. The sheath may be almost cartilaginous in consistency. The synovial surface is often discoloured and may have lost its normal sheen. Filmy adhesions are usually present round and between the tendons, and extend above more than below the styloid process. Occasionally a small excess of fluid is present, especially in patients operated upon shortly after the onset of symptoms.

Histology—Microscopically the features are those of a non-specific chronic inflammatory process which varies greatly in degree. The synovial layer is much more cellular than is usual. The lining cells are often numerous and prominent, being polyhedral or columnar in form rather than flattened. There are areas of mucoid change most obvious round the blood vessels. The blood vessels are numerous and thickened, and this thickening is apparent in capillaries as well as in arterioles and venules. It must be noted, however, that blood vessels in and adjacent to synovial membrane are normally thicker than those in other tissues.

The perisynovial fibrous tissue shows increased cellularity and collections of small round cells, mucoid changes and sometimes small areas of cartilage formation (Fig. 1). The small round-cell accumulations are almost invariably perivascular in distribution. The adhesions are composed of a fine areolar connective tissue which in long-standing cases contains a few blood vessels (Fig. 2). In long-standing cases the synovial membrane may also show a great deal more collagenous material than usual.

TREATMENT

Conservative measures, including immobilisation in plaster-of-Paris, were found useless. In all thirteen cases excision of the thickened sheath gave complete cure with no recurrence. General anaesthesia and a tourniquet are used. An adequate skin incision is made in the line of the tendons with its centre over the tip of the radial styloid. To quote de Quervain: "Care must be taken not to damage the sensitive branches of the radial nerve which run across this area towards the dorsum." A seeker is passed proximally through the canal and the sheath is excised. All the tendons present are then identified and the whole sheath excised, including the partition between the two tendons if a second compartment is present.

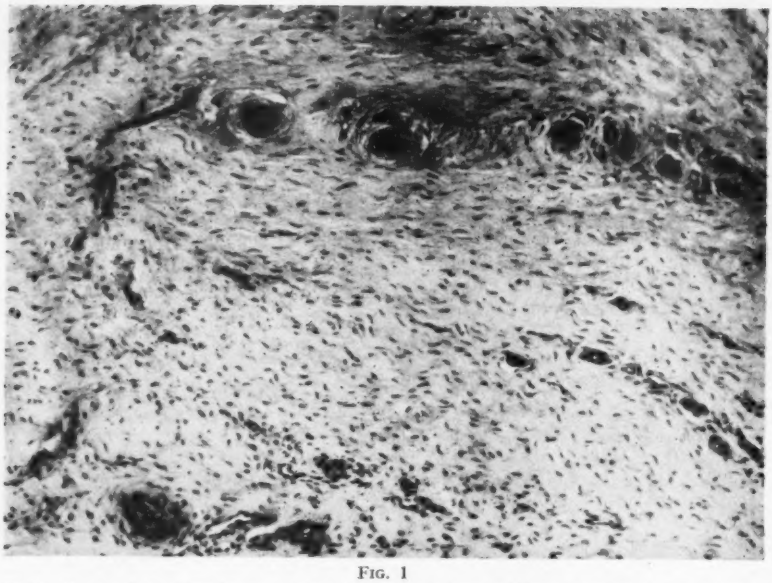

FIG. 1

Photomicrograph (×104) of part of the tissue taken from thickened tendon sheath showing fibrosis, thickening of small vessels, and some mucoid change which appears as loose (but more deeply staining) tissue round the vessels.

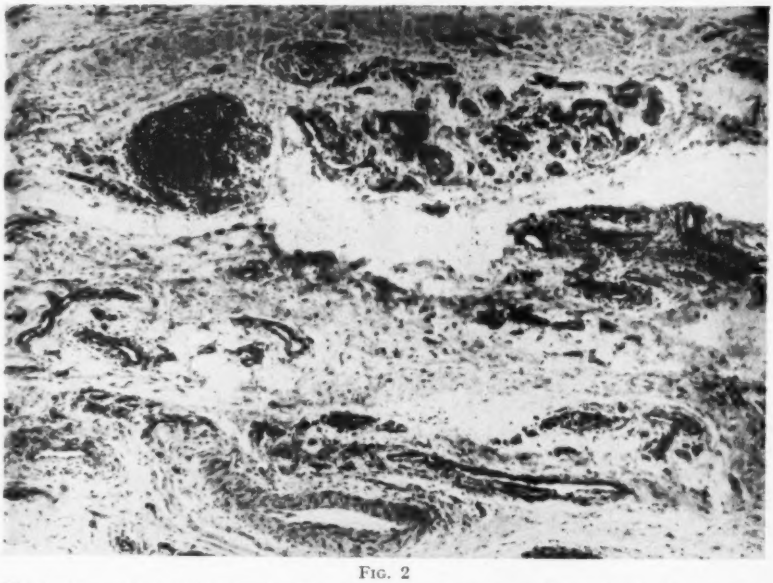

FIG. 2

Photomicrograph (×104) of part of the tissue taken from an adhesion showing perivascular accumulation of wandering cells, fibrosis and increase in the number of blood vessels.

The excision is radical, extending above and below the radial styloid and including any adhesions that are accessible. After suture of the wound the thumb and forearm are immobilised in a light plaster for ten to fourteen days.

Several facts are worthy of comment: *a*) In no patient operated on was there any swelling or constriction of the tendons as they passed through the thickened sheath. *b*) In all but one of these thirteen patients the abductor pollicis longus was represented by two or more tendons. In the exceptional case there were two separate osteofibrous canals and the extensor pollicis brevis tendon was equal in size to that of the abductor pollicis longus. *c*) In two cases the tendon of extensor pollicis brevis was only a small wisp which passed through a separate osteofibrous canal. Once it was recognised only with difficulty, being completely obscured by four slips of abductor tendon. Had its tendon sheath not been identified and excised, symptoms would no doubt have persisted. These facts are of particular interest because they have a definite clinical application.

Case Report—A man was admitted to hospital suffering from typical de Quervain's disease. He was operated on by a competent surgeon, who used local anaesthesia and a small "cosmetic" incision. The tendon sheath was exposed and incised; *two separate tendons were seen*. During the next year he obstinately refused to admit that he was cured. He complained of disagreeable paraesthesia over the thenar eminence and thumb and was finally suspected of malingering. At a second operation the tendon of abductor pollicis longus was found to be double (Fig. 3); the tendon sheath over it had obviously been incised and was causing no stenosis. The tendon of the extensor pollicis brevis, however, was abnormally large, passed through a separate osteofibrous canal, and was surrounded by a typically thickened synovial sheath, resection of which gave relief of symptoms.

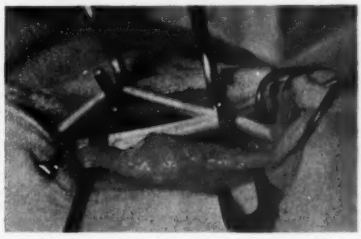

FIG. 3

The tendons exposed at operation. The tendon of abductor pollicis longus was double and was enclosed within a thin normal sheath. Extensor pollicis brevis was contained in a separate osteofibrous canal and its sheath was grossly thickened.

CONCLUSIONS

1. In patients who develop de Quervain's disease variations from the standard pattern of tendons at the wrist are the rule rather than the exception.
2. Conservative treatment is of no value.
3. Adequate exposure, allowing full recognition of all anatomical structures in the region, is advisable, but branches of the radial nerve must be treated with respect.
4. The extensor pollicis brevis tendon is normally small and may pass through a separate osteofibrous canal.
5. Though incision only of the stenosing tendon sheaths may be sufficient, thorough excision is more certain and does no harm.

My thanks are due to Mr E. S. J. King of Melbourne, who supplied the histological description of the lesion and the micro-photographs.

REFERENCES

BUNNELL, S. (1944): Surgery of the Hand. Philadelphia: J. B. Lippincott Company.

FINKELSTEIN, H. (1930): Stenosing Tendovaginitis at the Radial Styloid Process. Journal of Bone and Joint Surgery, **12**, 509.

QUERVAIN, F. DE (1895): Ueber eine Form von chronischer Tendovaginitis. Correspondenz-Blatt für Schweizer Aerzte, **25**, 389.

DIAPHYSIAL ACLASIS

Report of an Unusual Case

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From the Orthopaedic Department, St Mary's Hospital

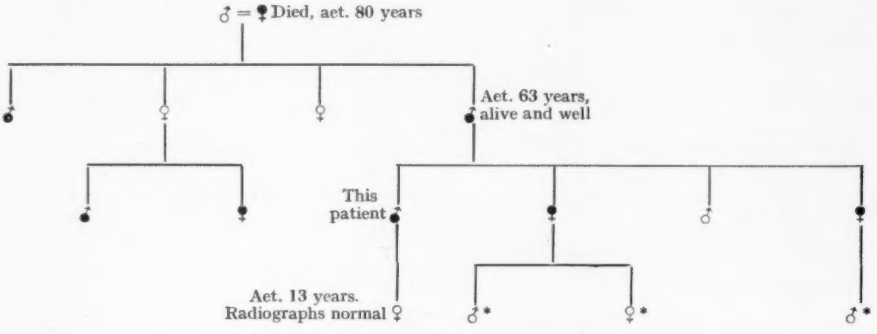
This case of diaphysial aclasis is described because it presents three unusual features: 1) sudden spontaneous growth of one of the exostoses, clinically malignant but not confirmed as such histologically; 2) associated congenital abnormality of the cervical vertebrae; 3) radiological appearance of some of the bones which might cause confusion with dyschondroplasia.

CASE REPORT

The patient was a factory gatekeeper aged forty years, whose mother had first noticed numerous hard swellings in his limbs and on his chest when he was three years old. At the age of fifteen, during the course of a year, his left arm became almost completely paralysed below the elbow, with loss of sensation; and at about this time two of the bony swellings in the left arm were removed. Eighteen months before admission, a swelling which had always been present in the upper part of the left thigh began to grow and a few months later it became painful. He came into hospital because of difficulty in getting his trousers over the swelling. None of the other bony swellings had shown any increase in size since he stopped growing, and his general health had been good.

Family history—A similar condition was present in three successive generations (Fig. 1).

Examination—His general condition was satisfactory. His height, sixty-two inches, was below average. Bony tumours and deformities were widely distributed as the photograph (Fig. 2) and radiographs (Figs. 3 to 7) show. The left side of the body was more severely affected than the right. The tumour of the left thigh was twenty-nine inches in circumference and eleven and a half inches in its vertical length. It was hard; the skin was stretched tensely over it but was not adherent; the skin temperature was not increased. Mechanical interference by the tumour limited flexion at the left hip joint by 40 degrees. The chest was deformed with two antero-lateral sulci, the right deeper than the left. Most of the sternal head of the left pectoralis major was absent (Fig. 2). There was a thoracic kypho-scoliosis of the spine with convexity to the right, with slight restriction of movement in all directions and



* *Thought to be normal but examination refused.*

FIG. 1

Family history. The black signs indicate the members of the family affected by diaphysial aclasis.

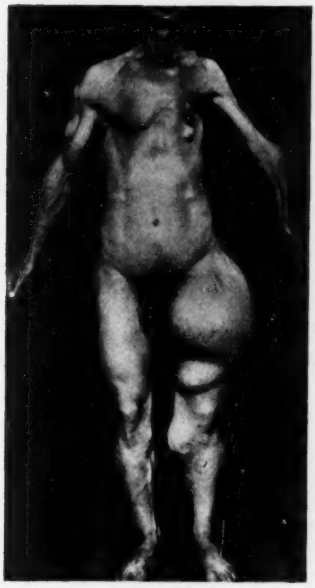


FIG. 2

Photograph of the patient showing the multiple swellings, gross enlargement of the left thigh, absence of most of the sternal part of the left pectoralis major muscle, and the thoracic deformity.

FIG. 3

FIG. 4

Figure 3—The left femur. Dense areas of calcification are scattered throughout the large tumour mass.
Figure 4—The left knee joint, showing marked overgrowth of the medial tibial condyle capped by a large densely calcified chondroma.

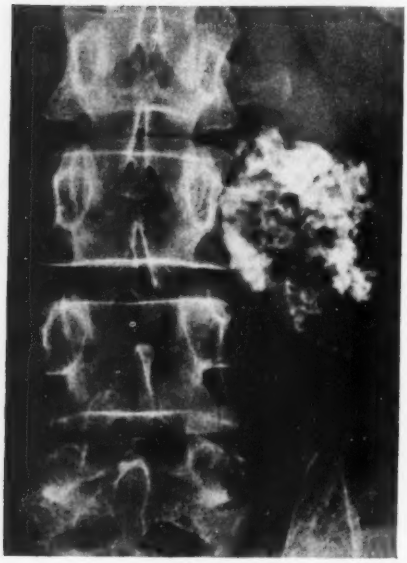


FIG. 5

Calcified chondroma arising from the third left lumbar transverse process.

FIG. 6

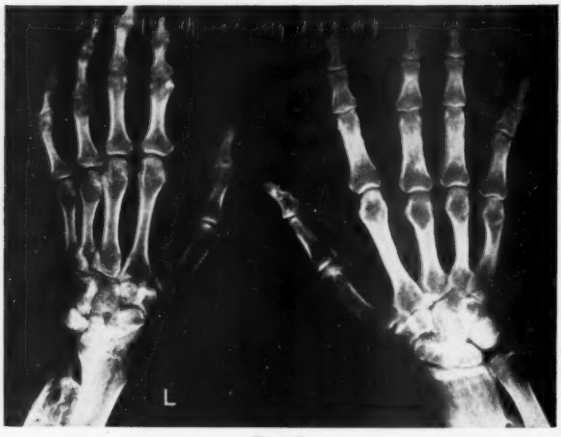


FIG. 7

Figure 6—Cervical spine, showing fusion of the bodies and of the spinous processes of the fourth and fifth, and the sixth and seventh, vertebrae. Figure 7—The hands and wrists. In the right hand there is lack of modelling of the phalanges and metacarpals. The lower end of the left ulna is ill-formed and stunted, a well recognised feature of diaphysial aclasis.

considerable limitation of cervical rotation. The left clavicle was bowed over a tumour, two inches in diameter, which arose from the left first rib and had caused a left brachial plexus lesion of lower trunk type (C.8 and T.1) affecting the left arm. The cardio-vascular and respiratory systems were normal, except for limited thoracic respiratory movement. The liver edge was palpable two fingers' breadth below the costal margin but no irregularity could be felt on its surface. The blood picture was normal.

It was considered that malignant change had occurred in the previously benign tumour in the left thigh. As there was no evidence of metastases, disarticulation at the hip was undertaken. It was just possible to ligate the vessels immediately below the inguinal (Poupart's) ligament and to perform the disarticulation without cutting into tumour substance.

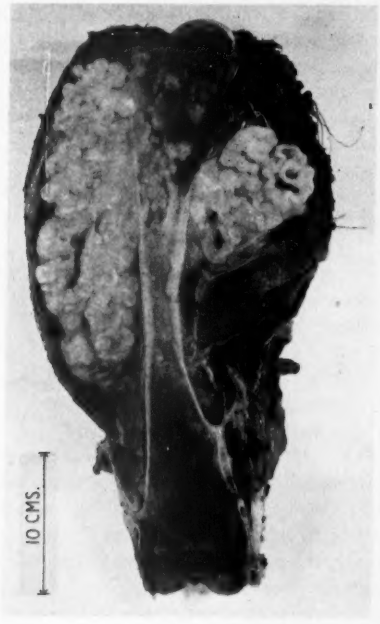


FIG. 8

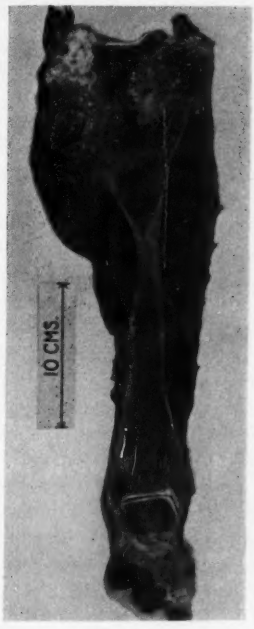


FIG. 9

Macroscopic appearance of the tumour of the left femur (Fig. 8), and of the upper end of the left tibia (Fig. 9).

After operation the patient's condition was satisfactory until the second day when, after a standard dose of morphine derivative, he became comatose for several hours. Next day, his condition again appeared satisfactory, but on the fourth day he complained of abdominal pain, his condition steadily deteriorated and he died.

Autopsy—The cause of death was peritonitis from perforation into the lesser sac of a small acute peptic ulcer on the greater curvature of the stomach near the cardia. Thorough examination of the whole body revealed no secondary neoplastic deposits. The tumour of the left thigh was cartilaginous in nature. It involved the shaft of the femur and was adherent to the surrounding muscles which were partly fibrosed (Fig. 8).

Histological examination (Professor W. D. Newcomb)—There was no unequivocable evidence of invasion of the muscle but several small outlying nodules of tumour appeared to invade

the fibrous tissue. The cytology of the tumour varied from large degenerate cartilage cells to small spindle and angular cells forming reticulin and collagen. Some cells were binucleated but no mitotic figures were seen. It was impossible on histological grounds either to confirm the clinical suspicion of malignant change or to prove that the tumour was benign.

DISCUSSION

In this case the rapid increase in size of a pre-existing exostosis, with pain, many years after general cessation of bone growth, strongly suggested malignant change, and radical surgery was clearly indicated. The diagnosis of malignancy in diaphysial aclasis must be made chiefly on clinical grounds because of the uncertainty of histological diagnosis of chondrosarcoma. Increase of symptoms in an adult—renewed growth and pain—must generally be regarded as evidence of malignancy. Platt (1931), however, stated that rapid growth and large growth are not in themselves pathognomonic of malignant change in a chondroma. Jaffe (1943) considered that malignant transformation in diaphysial aclasis took the form of chondrosarcoma, not of osteogenic sarcoma: chondrosarcoma may originate in the cartilaginous cap of an exostosis or its residuum, or from a subperiosteal cell-rest. Jaffe and Platt both mentioned the difficulty of histological diagnosis. Chondrosarcoma arising in diaphysial aclasis is not usually highly malignant; it tends to remain only locally invasive for some years; distant metastases occur late and in many cases not at all (Jaffe 1943, Geschickter and Copeland 1949, Willis 1948, Gardner 1937).

The incidence of malignant transformation is difficult to determine because so many minor cases of diaphysial aclasis are not seen by surgeons. Jaffe found 11 per cent (three out of twenty-eight cases). Bennett and Berkheimer (1941), Gardner (1937), on the other hand, thought that it was rare. It almost certainly occurs more often in adults than in children.

The recommended treatment of clinically diagnosed malignant change in an exostosis is local resection, if technically possible; amputation at the site of election above the tumour is necessary in advanced growths. X-ray therapy is of doubtful value. It should be tried in inoperable growths or if operation is refused.

The abnormality of the cervical vertebrae—Fusion of vertebrae, as in this case (Fig. 6), is not one of the recognised features of diaphysial aclasis. Fairbank (1949) stated that exostoses may affect the neural arches but seldom the vertebral bodies; he did not mention fusion. Keith (1920) stated that in diaphysial aclasis all bones formed entirely within cartilage or entirely within membrane—the tarsal and carpal bones, the epiphyses of the long bones, the sternum, the vertebral bodies, and the bones of the cranial vault and face—are free from the disorder; it is confined to those parts of the skeleton where bone laid down in cartilage becomes covered with periosteal bone. He considered that there was an arrest of development in the periosteal ring (or ferrule) which permits the cartilage of the growth disc to be exposed on the surface, thus leaving it uncovered and free to give rise to the exostoses. The question arises then whether the fusion of the cervical vertebrae in this case could be part of the generalised diaphysial aclasis, or whether it was a separate and coincidental congenital abnormality. According to Stocks and Barrington (1925) bones formed strictly in cartilage or in membrane are not invariably spared, as stated by Keith, but are occasionally the site of an exostosis. If so, fusion of vertebral bodies might be part of the disorder. These authors also mention the occasional occurrence of scoliosis or kyphosis, or both, and thoracic deformities similar to those of rickets, which abnormalities were present in this case.

Differentiation of diaphysial aclasis from dyschondroplasia—The radiographs in this case showed more calcified cartilage than that usually seen in diaphysial aclasis. This might suggest dyschondroplasia, in which speckled calcification occurs in the affected areas of the diaphyses and epiphyses as the subject grows older (Hunter and Wiles 1935). But the masses of calcified cartilage sometimes seen in diaphysial aclasis are not endosteal as in dyschondroplasia;

they are caused by local disturbances of endochondral ossification in the proliferating cap of hyaline cartilage overlying the exostosis (Jaffe **1943**) (Fig. 9). Small exostoses may arise near the epiphyses of the long bones in dyschondroplasia, but they are rough and irregular, may point in any direction and do not grow large; they are unlike those of diaphysial aclasis. In dyschondroplasia the expansion of the ends of the long bones—a significant feature of diaphysial aclasis—is very seldom seen.

The asymmetrical distribution of the lesions in our case might also suggest dyschondroplasia. In fact, however, dyschondroplasia may be symmetrical or asymmetrical; and in diaphysial aclasis, though the distribution of exostoses is usually fairly symmetrical, it is not always so. There is no evidence of a hereditary factor in dyschondroplasia. Radiographs of the hand showed only defective modelling of the phalanges and metacarpals. There were no enchondromata such as may occur in dyschondroplasia. Jaffe (**1943**) maintained that dyschondroplasia and diaphysial aclasis are unrelated, because the two conditions do not occur in members of the same families, and enchondromata do not occur in association with exostoses; he suggests that faulty interpretation of radiographs (perhaps taken only in one plane) may be the cause of confusion between the two conditions.

REFERENCES

Bennett, G. E., and Berkheimer, G. A. (1941): Surgery, **10,** 781.

Fairbank, H. A. T. (1949): Journal of Bone and Joint Surgery, **31–B,** 105.

Gardner, E. K. (1937): British Journal of Surgery, **25,** 323.

Geschickter, C. F., and Copeland, M. M. (1949): Tumors of Bone. Third edition. Philadelphia and London: J. B. Lippincott & Co.

Hunter, D., and Wiles, P. (1935): British Journal of Surgery, **22,** 507.

Jaffe, H. L. (1943): Archives of Pathology, **36,** 335.

Keith, A. (1920): Journal of Anatomy, **54,** 101.

Platt, H. (1931): Proceedings of the Royal Society of Medicine (Section of Orthopaedics), **25,** 71.

Stocks, P., and Barrington, A. (1925): The Treasury of Human Inheritance. Vol. 3, part 1.

Willis, R. A. (1948): Pathology of Tumours. London: Butterworth & Co. (Publishers) Ltd.

CAVERNOUS HAEMANGIOMA OF THE KNEE JOINT

Report of a Case

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and

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A girl aged eight and a half years complained of swelling and discolouration of the left leg with chronic pain in the knee and a limp made worse by exercise. A patchy birthmark extending from hip to heel had been treated with radium at the age of eighteen months. Aching pain in the knee had been present for five years. There was nothing relevant in the family history.

FIG. 1
After operation. The birthmark is evident.

On examination general health was good. In the left lower limb a bluish mottling of the skin, due to a diffuse cavernous haemangioma, extended from the left buttock to the heel (Fig. 1). Swelling of the knee affected mainly the suprapatellar region. The swelling was suggestive of fluid within the joint, but differed from a fluid effusion in being compressible. It was not affected by elevation of the limb. Only the extremes of joint movement were limited. There was no crepitation. The legs were equal in length. There was slight wasting of the thigh and calf. Radiographs showed no bony abnormality and no soft-tissue shadow. The Mantoux test (1: 100) was negative. The Wassermann reaction was negative. The blood cholesterol was normal and the erythrocyte sedimentation rate was 2 millimetres in the first hour. Cavernous haemangioma of the knee was diagnosed.

At operation, a diffuse extra-synovial cavernous haemangioma was found bulging into the suprapatellar pouch and holding the patella away from the femur. It gave rise to the sensation of patellar tap, but there was no fluid in the joint. Boiling water was injected into the mass of veins, which shrivelled up immediately. The knee was closed without drainage.

Since the operation the patient has been free from symptoms. The scar shows some tendency to haemangiomatous change. A small swelling is still present and patellar tap can be elicited though less easily than before operation.

DISCUSSION

Cavernous haemangioma of the knee joint, although uncommon, gives a characteristic clinical picture. Only forty cases had been recorded up to 1939, when the literature was completely reviewed by Bennett and Cobey. Since then eleven further cases have been recorded (Cobey 1943, Cole and Hunt 1949, Harmon 1943). In the knee joint

the tumour occurs in two forms: in one there is extensive, diffuse involvement of the synovial membrane associated with a naevoid condition of the leg; in the other there is a localised pedunculated mass. The symptoms of both types are usually similar.

Patients are commonly brought for advice early in life, as with the superficial types of haemangioma. Females are affected more commonly than males. In almost every instance there is a story of intermittent swelling of the joint associated with pain and limp. Injury is sometimes mentioned, but is probably only a precipitating factor. During the exacerbations the knee may be tender. Limitation of the extremes of movement and a sensation of a spongy mass are usual. In many cases the mass is compressible or is diminished by elevation of the limb. Crepitation is uncommon. The limb may be longer than the other. Moderate atrophy of the thigh muscles is usual. An associated superficial naevus often suggests the correct diagnosis. Radiographic examination is essentially negative—as distinct from the cases in which haemangioma involves bone—though a soft-tissue shadow may be detected. The condition may be differentiated from tuberculosis, syphilis, traumatic effusion, internal derangement of the knee joint, chronic infective arthritis, and xanthomatous or hypertrophic villous arthritis.

Treatment. *Injection of sclerosing fluids*—Various chemical sclerosants have been tried but reports have not been encouraging. Our preference, based on experience of the usual types of cavernous haemangioma (Cole and Hunt 1949), is for thermal sclerosis by the injection of boiling water (Wyeth 1903).

Excision—This is the ideal treatment in the pedunculated type. In the diffuse type it is difficult and the result is uncertain (Bennett and Cobey 1939). Successful results have been claimed after synovectomy (Harmon 1943).

X-ray therapy—The results of X-ray therapy are reported to be satisfactory (Bennett and Cobey 1939, Cobey 1943).

REFERENCES

BENNETT, G. E., and COBEY, M. C. (1939): Archives of Surgery, **38**, 487.
COBEY, M. C. (1943): Archives of Surgery, **46**, 465.
COLE, P. P., and HUNT, A. H. (1949): British Journal of Surgery, **36**, 346.
HARMON, P. H. (1943): Archives of Surgery, **47**, 359.
WYETH, J. A. (1903): Journal of the American Medical Association, **40**, 1778.

ATLANTO-AXIAL FRACTURE-DISLOCATION

Report of a Case

G. O. TIPPETT, LONDON, ENGLAND

A stockily built man of fifty-eight years was thrown from his horse in December 1947 and landed heavily on the right side of his face. He was dazed for a few seconds but on recovering he noticed pain and " pins and needles " radiating down both arms and inability to move the upper or lower extremities. After a few minutes the pain and tingling disappeared, movement returned in the arms and legs and the patient then was conscious of intense pain in his neck, partly relieved by supporting his chin with his hands. Radiographs were deceptive and he was thought to have sustained a simple contusion. Later in the day he had some difficulty in swallowing, which increased until food and drink were regurgitated through the nose. Speech became thick and nasal and there was a feeling of obstruction to breathing which

FIG. 1

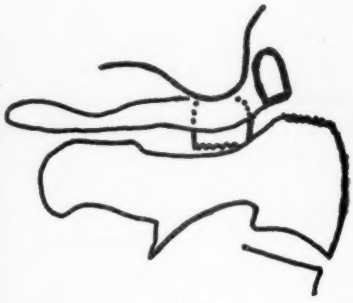


FIG. 2

Figure 1—Radiograph of the cervical spine taken shortly after the injury. Note fracture through the base of the odontoid process. The atlas vertebra, carrying with it the odontoid peg and the occiput, has been displaced markedly backwards. Figure 2 is a tracing from the radiograph.

greatly alarmed the patient. The sense of taste was lost. The left occipital part of the scalp became so sensitive that he could not brush his hair and there was severe and persistent neuralgia over the whole occipital region.

Examination showed considerable swelling and tenderness over the upper part of the neck; gross restriction of neck movements, the head being held rigidly in extension and the chin supported by the hands; swelling of the back of the pharynx and paralysis of the left side of

the soft palate; irregularity of the posterior pharyngeal wall palpable through the mouth; and marked hyperaesthesia of the occipital region of the scalp. There were no motor, sensory or reflex abnormalities in the arms or legs.

Radiographs (Fig. 1) disclosed: 1) fractures of the anterior arch and right lateral mass of the atlas; 2) a fracture through the base of the odontoid process; 3) backward displacement of the odontoid, the atlas and the skull in relation to the axis; 4) osteoarthritis of the mid-cervical spine.

Treatment—A plaster-of-Paris jacket of the "Minerva" type was applied without an anaesthetic after the head had been gently coaxed from the extended to the neutral position. It was felt undesirable to attempt accurate reduction lest the cord be damaged in the process. Much difficulty was encountered in making the patient comfortable because the hyperaesthesia and the occipital neuralgia made a closely fitting collar intolerable. Nevertheless, moderately effective immobilisation in a collar was maintained for three months. Six months after the accident there was a fair range of painless movement, speech and swallowing were normal, and there were only transient pains in the occipital region. Three years after the accident the patient wrote as follows: " The movements of my neck have loosened up considerably, though there is still a certain limitation to the freedom of my movement. I started swimming nine months after the accident and riding a little later. The tenderness of the scalp was the thing that troubled me longer than anything else. Now it sometimes returns, but only in connection with headaches I derive from colds or overwork."

Comment—Atlanto-axial fracture-dislocation is an uncommon injury (Crooks and Birkett 1944) which has been well described by Jefferson (1920, 1927) and by Plaut (1938). It is not accompanied by severe involvement of the cord or by death as frequently as is dislocation of the atlas on the axis *without* a fracture of the odontoid. The present case is an example of an injury produced by hyperextension which, in people of this age group with cervical osteoarthritis, can have even more serious consequences (Barnes 1948).

In addition to the clinical picture which characterises fractures and fracture-dislocation of the cervical spine, atlanto-axial fracture-dislocations present special signs occasioned by certain anatomical relationships. Thus there may be severe occipital neuralgia and hyperaesthesia of the back of the scalp due to involvement of the great and sub-occipital nerves which are intimately related to the postero-lateral arches of the atlas. Secondly, there may be dysphagia and alterations in speech and taste due to tearing and bruising of the constrictor muscles of the pharynx and injury to the corda tympani, glossopharyngeal and palatal nerves. It is important to be aware of these classical signs of the injury, for radiographs of the occipito-cervical region may be obscured by the mastoid air cells and are often difficult to interpret unless stereoscopic views or tomograms are available.

REFERENCES

AKERMAN, J. (1932): Acta Chirurgica Scandinavica, **71**, 23.
BARNES, R. (1948): Paraplegia in Cervical Spine Injuries. Journal of Bone and Joint Surgery, **30–B**, 234.
CROOKS, F., and BIRKETT, A. N. (1944): Fractures and Dislocations of the Cervical Spine. British Journal of Surgery, **31**, 252.
HAMBLY, E. H. T. (1944): Lancet, **ii**, 851.
JEFFERSON, G. (1920): Fracture of Atlas Vertebra. British Journal of Surgery, **7**, 407.
JEFFERSON, G. (1927): British Medical Journal, **ii**, 153.
JEFFERSON, G. (1940): Proceedings of the Royal Society of Medicine (Section of Orthopaedics), **33**, 657.
PLAUT, H. F. (1938): American Journal of Roentgenology, **40**, 867.

FIRST RECURRENCE OF OSTEOMYELITIS EIGHTY YEARS AFTER INFECTION

W. E. GALLIE, TORONTO, CANADA

This report concerns a female patient who developed acute osteomyelitis of the right femur at the age of ten years and who had the first secondary flare at the age of ninety years. No records of her early history are available but the patient has an excellent memory and recalls vividly the onset of pain, the fever and the swelling, the weeks of poulticing, and finally the incision without anaesthesia and the year of drainage and dressings that followed.

FIG. 1

Radiograph at the age of ninety years. Note the typical appearances of old osteomyelitis with thickening sclerosis, cavitation and sequestrum formation. There had been no symptoms for eighty years.

After the operation she rapidly returned to good health and after the wound had healed never had a symptom or sign until the recent episode. In the interval she had lived a healthy and vigorous life, had raised a large and robust family, and had gradually and happily slid

into those years of the "sear, the yellow leaf" without much appreciation that they are sometimes described as "declining." Then about three years ago she began to notice a throbbing and an aching pain in the lower end of the femur in the neighbourhood of the scar, and it was discovered that she was running a low-grade fever.

Examination showed an old scar on the lateral aspect of the thigh. The lower third of the femur was much thickened and slightly tender. The temperature rose daily to 100° F. and there was a mild polymorphonuclear leucocytosis. Radiographs showed a typical old osteomyelitis with a Brodie's abscess in which was a small sequestrum (Fig. 1).

Treatment—A course of penicillin gave only temporary improvement and resort was had to the older stand-by of poulticing. When the abscess was well ripened it was incised; a drill-hole

FIG. 2
Photomicrograph of a section of the sequestrum.

was made into the cavity and yellow pus under slight pressure escaped. A cavity one and a half inches long and an inch wide was uncovered and a sequestrum one inch long was removed. The cavity was partly saucerised and vaseline gauze inserted. The wound healed in a few weeks and the patient has remained well since the operation. Examination of the pus showed staphylococcus aureus.

Comment—There is nothing unusual about this case except that the interval between the outbreaks was so long. One cannot help wondering, however, whether the staphylococci we discovered were the same that caused the original trouble or whether they were their sons or grandsons. Indeed they may not have been of the same family of staphylococci at all but only some wayfarers who found a place made suitable for them by their predecessors of eighty years ago.

The presence of a sequestrum was surprising. One would have thought that after all those years it would have dissolved or succumbed to the attacks of scavengers. Yet there it was, white, avascular, and devoid of osteocytes in the lacunae (Fig. 2). The surface was much pitted and in the pits were masses of granulation tissue which in places extended into the interior of the bone. But there was none of the creeping replacement so characteristic of rarefying osteitis and of the rapid absorption and replacement that happens in an autogenous bone graft, and no sign whatever of new bone. One can only conclude, therefore, that it is hardly worth while to wait for the absorption of a sequestrum and that it had better be removed as soon as it is loose.

DISRUPTION OF THE PELVIS

Report of a Case

THOMAS F. ROSE, SYDNEY, AUSTRALIA

The patient, a youth aged seventeen years, was speeding on a motor cycle when he hit a stationary lorry. He was flung through the air and struck the tail-board of the lorry. He then fell to the ground on his right wrist.

Seen in hospital soon after the accident he was found to be very much shocked; he complained of severe hypogastric and sacral pain. Apart from a few abrasions on the lower jaw and a fracture of the right wrist, his main injury was confined to the pelvis. There were many superficial skin abrasions and a large haematoma in the supra-pubic region. The scrotum was thickened with an effusion of blood which also involved the urogenital triangle of the perineum. There was generalised abdominal tenderness and rigidity most marked in the lower abdomen. Palpation of the pubis disclosed a separation of the symphysis wide enough for three fingers to be sunk between the joint surfaces. Posteriorly there was tenderness over both sacro-iliac joints. Rectal examination revealed nothing abnormal. There was no evidence of injury to the bladder. A catheter was passed without difficulty and clear urine was withdrawn. Neither then nor afterwards was there any interference with micturition.

The patient was treated for shock with a transfusion of one litre of stored blood. Twelve hours after admission his condition had improved and a radiograph (Fig. 1) showed wide separation of the symphysis pubis and dislocation of both sacro-iliac joints, the right being the more severely displaced. Under anaesthesia it was found that both hip bones could be moved freely on the sacrum. The disruption of the symphysis could be easily accentuated or reduced by gentle manipulation. The patient was placed on his left side on an orthopaedic table. The two halves of the pelvis then came and stayed easily together as described by Watson-Jones (1943).

Reduction was confirmed by radiography (Fig. 2), and a double hip-spica was applied. He was nursed in this on his left side for three months. The spica was then removed and he was allowed to walk about. There was no pain in the pubic or sacro-iliac regions. A radiograph showed that reduction had been maintained.

When seen twenty months after the injury the patient said that he was able to carry on his occupation, which necessitated standing at a work bench all day. His week-end pastime was hiking and he was able to walk twenty or more miles over bush tracks carrying a heavy pack. This exertion caused no symptoms referable to his injury. Examination showed an apparently normal pelvis. The symphysis pubis was united and the sacro-iliac joints were stable. There was no local tenderness. Spinal movements were full and painless. The hip joint movements and gait were normal. A radiograph of the pelvis (Fig. 3) showed very slight widening of the symphysis pubis. The sacro-iliac joints appeared normal.

Comment—The interesting feature about this patient's injury is the severe damage to the pelvis without any bladder involvement whatever. It also illustrates the efficacy of the Watson-Jones conservative method in the treatment of such a condition.

I wish to thank the Superindendent of The Royal North Shore Hospital for permission to publish this report.

REFERENCE

WATSON-JONES, R. (1943): Fractures and Joint Injuries. Third edition. Edinburgh: E. & S. Livingstone Limited. p. 378.

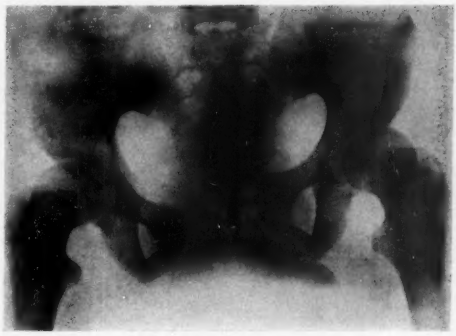


FIG. 1

Radiograph taken soon after the injury shows wide separation of the symphysis and disruption of the sacro-iliac joints, particularly the right. Despite the gross displacement there was no clinical evidence of injury to the bladder or urethra.

FIG. 2

The displacement was reduced perfectly by lateral recumbency.

FIG. 3

Twenty months later there was no significant widening of the symphysis. The functional result was excellent.

STATUE OF JOHN HUNTER
IN THE MUSEUM OF THE ROYAL COLLEGE OF SURGEONS

SPECIMENS FROM THE HUNTERIAN COLLECTION

R. J. LAST, LONDON, ENGLAND

Professor of Applied Anatomy, Royal College of Surgeons

It is proposed to illustrate with photographs a series of specimens of orthopaedic interest in the anatomical museum of the Royal College of Surgeons of England, and the first examples appear in this number of the Journal.

The museum of the Royal College of Surgeons of England began as the collection of specimens left by John Hunter at his death in 1793. Hunter had retired from the army thirty years earlier and began practice in London. Among the surgeon-anatomists of those days he was pre-eminent as an experimenter and a thinker. He extended his researches into the whole realm of living things, plant and animal, vertebrate and invertebrate. He was a great comparative anatomist and perhaps his most consuming interest lay in the investigation of form and how it varies according to functional needs. Examples illustrating the interplay between form and function were collected and kept by Hunter, until at his death there were some 14,000 specimens in his private collection. They represented his life's work and, incidentally, almost his whole fortune. Indeed, his executors were forced to raise money to support his wife and children. After some seven years the Government of the day purchased Hunter's specimens as a collection for the nation.

At the granting of the Royal Charter to the (then) Company of Surgeons the Royal College of Surgeons was founded in 1800, and the Hunterian collection was entrusted to its care. The collection did not remain static. Under the guidance of succeeding conservators of the museum a constant inflow of new specimens was maintained. These specimens were then as now derived from two main sources. First, the prosectors of the college produced specimens to augment the collection and, second, a large number of private gifts and bequests served still further to enlarge and complete this unique collection. With growth in size came the need for more accommodation, and gradually more rooms were added. The collection had increased fivefold from the original 14,000 Hunterian specimens. Then came the disaster of 1941.

At the outbreak of war the specimens had been stored in the basements of the college buildings, where expert opinion had pronounced that they would be safe from blast. This proved to be correct, but the bomb that destroyed so much of the college building was followed by a fire whose heat burst many of the bottles. The specimens were mounted for the most part in spirit, and so the fire spread. Two-thirds of the collection was lost.

At the end of the war the surviving specimens were again put on display in the limited space available and the work of rebuilding the collection commenced. The present prosector is producing incomparable human dissections, and a number of invaluable gifts of specimens have been received. Details can be found in the annual Scientific Reports of the college. For the interest of those able to make a personal visit to the museum it is worth noting the different colours in which the catalogue numbers are painted on the jars. Hunter's original specimens are labelled in black, post-Hunterian additions up to the late war in red, and post-1945 current additions in blue. A further characteristic of the current additions is the fact that they are mounted in " perspex," whose flat surfaces and great transparency give to the specimens an undistorted lucidity that cannot be obtained with glass jars.

There is little of orthopaedic interest in any surviving Hunterian specimens. Hunter's human specimens appear in various sections as incidental members of the sum total of living things, and are not there as human anatomy for its own sake. The existing human anatomy part of the museum is entirely post-Hunterian, much of it, indeed, post-1945, and it is from this section that the present and subsequent photographs and descriptions are taken.

1. THE LIGAMENTS OF THE TARSUS

SPECIMEN S 97 B

Lateral view—The three fasciculi of the lateral ligament of the ankle joint can be seen; the obliquity of the calcaneo-fibular ligament is very pronounced, even in full dorsiflexion. The posterior talo-calcaneal ligament is preserved. Note the strong ligamentum cervicis tali occupying the anterior part of the sinus tarsi.

More anteriorly a glass rod has the strong calcaneo-navicular part of the bifurcate ligament glistening on its far side. In this specimen, as in so many, the calcaneo-cuboid part of the bifurcate ligament is absent, the dorsal calcaneo-cuboid ligament alone being present. The calcaneo-navicular fasciculus is always present, is always strong, and always articulates with the head of the talus, its articular surface being covered, like that of the spring ligament, with fibrocartilage.

Specimen S 97 B

Specimen S 97 B

Inferior view—The long plantar ligament is attached mainly to the ridge behind the groove on the cuboid, but some of its superficial fibres bridge the groove and pass to the bases of the second, third and fourth metatarsal bones. The tunnel so produced lodges the tendon of peroneus longus. It is to be noted that the tendon does not lie in the depths of this tunnel, but that its pull draws it posteriorly, and it is on the posterior part of the slope of the cuboid that articular fibrocartilage is found. A sesamoid fibrocartilage (often ossified) lies in the contiguous part of the tendon of peroneus longus. The short plantar ligament, much thicker, lies more obliquely.

The fibres of the inferior calcaneo-navicular (or "spring") ligament lie more nearly transverse than longitudinal in the foot. A glass rod lies beneath the deep part of the medial (deltoid) ligament of the ankle, which connects the medial malleolus to the neck of the talus.

2. THE INTEROSSEOUS LIGAMENTS OF THE WRIST

SPECIMEN S 15 A

The great preponderance of transversely running fibres on the anterior surface of the carpus is well seen in this specimen. A particularly powerful band passes from the radial styloid and adjacent bone to the lunate. (On the dorsum of the wrist there is a similar transverse band, but attached to the triquetral and leaving the lunate free.) More proximally a strong ligament joins the lower border of the radius to the ulnar styloid; this ligament blends inseparably with the triangular fibrocartilage. The radio-ulnar joint has been opened by removal of its thin capsule; note the proximal prolongation of the joint space between radius and ulna. This is the membrana sacciformis; it lies between the interosseous membrane and the pronator quadratus muscle.

Of particular interest in this specimen is the tunnel for the tendon of flexor carpi radialis, here occupied by a glass rod. The tendon pierces the flexor retinaculum over the scaphoid, *is often attached to the scaphoid,* and then passes beneath this strong ligament joining the ridge of the trapezium to the capitate. An optical illusion in the photograph gives a false appearance of translucency to the ligament. The ligament is highly illuminated; the adjacent edge of the trapezium shows darkly and gives a false appearance of being the glass rod showing through the ligament. In fact the ligament is very thick. The synovial sheath of flexor carpi radialis extends distally into the fibro-osseous canal in which the glass rod is lying.

The ulnar side of the carpal tunnel for the flexor tendons consists of the pisiform and the hook of the hamate. The pisihamate ligament is well shown; it consists of two bands diverging from the pisiform, one to the hook of the hamate and the other, more medially, to the ulnar border of that bone. The pisimetacarpal ligament, overlying the latter band, has been removed. The deep transverse ligament of the metacarpal heads is well shown.

CHANGES IN THE FEMORAL HEAD UNDERLYING A VITALLIUM CUP

ALEXANDER GIBSON and THOMAS H. WILLIAMS, WINNIPEG, CANADA

From the Departments of Orthopaedic Surgery and Pathology, Deer Lodge Hospital

The opportunity of examining the head of a femur that has been subjected to vitallium cup arthroplasty occurs but seldom. We have observed two cases, each with a very different post-operative history.

Case 1—Housewife, aged sixty-three years. Vitallium cup arthroplasty was performed in March 1941 for osteoarthritis of the right hip. One year previously the right breast had been removed for carcinoma. The operation was followed by thrombophlebitis in the right leg.

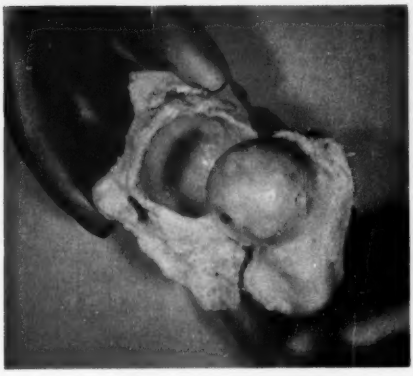


FIG. 1

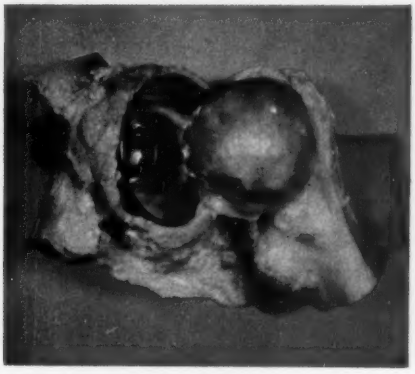


FIG. 2

Case 1—Macroscopic appearance of the joint surfaces one year after cup arthroplasty.

FIG. 3

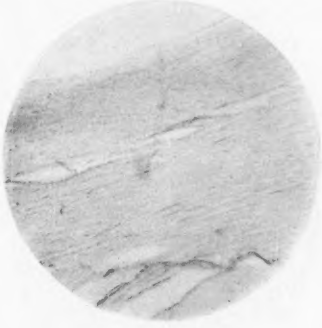


FIG. 4

Case 1—Microscopic sections of the femoral head. Figure 3 shows cancellous bone with osteoblasts; no cartilage cells. Figure 4 shows parallel layers of collagenous fibrous tissue at the surface, but no cartilage cells.

When she was readmitted to hospital in 1942 there was evidence of carcinomatous metastases in the supraclavicular glands, within the thorax, and in the fourth and sixth thoracic vertebral

FIG. 5

FIG. 6

Case 2—Macroscopic appearance of the joint surfaces three years and eight months after cup arthroplasty.

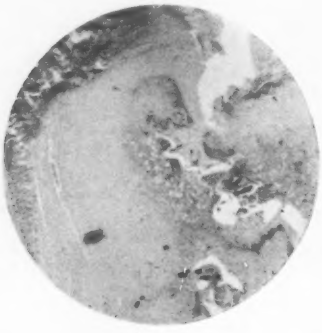


FIG. 7

FIG. 8

Case 2—Microscopic sections of the femoral head. Figure 7 shows cancellous bone and cartilage cells. Figure 8 shows the articular surface in which cartilage cells are present.

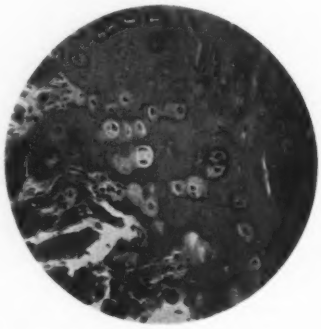


FIG. 9

Fig. 10

Case 2. Figure 9—High-power magnification of the area shown at the centre in Figure 7. Note cartilage cells laid down *de novo* over bone made raw at time of operation. Figure 10—Section from acetabular rim showing cartilage cells at articular surface.

bodies. She died soon after admission, one year after the cup arthroplasty had been performed.

Autopsy—Death was from generalised carcinomatosis. The joint capsule of the right hip was continuous and normal in thickness. The vitallium cup was found in the acetabulum and was movable both in the socket and on the femoral head. There were many exostoses above the acetabulum. The surface of the femoral head was dull pink with irregular pale mottling (Figs. 1 and 2).

Histological examination of the head of the femur (Figs. 3 and 4) showed cancellous bone with marrow cells in the interspaces. One small area of metastatic carcinoma was seen in the marrow. In places there was evidence of deposition of bone by osteoblasts. No cartilage was seen, but the bone was covered directly by collagenous fibrous tissue which was loose at the bone margin and arranged in dense parallel layers below the articular surface. In some places at the surface there was a very loose collagenous degenerative appearance which explained the mottling seen macroscopically (Fig. 4). No cartilage cells were seen at the surface.

Case 2—Musician, aged fifty-eight years. Cup arthroplasty was done in 1946 for osteoarthritis of the right hip joint. The operation was followed by prolonged physiotherapy, and the patient gained an excellent range of movement.* Three years later a cough began; investigations showed bronchogenic carcinoma with supraclavicular metastases. He died in December 1949, three years and eight months after the cup arthroplasty.

Autopsy confirmed that death was due to squamous bronchogenic carcinoma of the right upper lobe with widespread metastases. The joint capsule of the right hip was complete and normal in thickness. The vitallium cup moved freely in the acetabulum, and the femoral head moved freely in the cup. The rounded head of the femur was covered by a smooth bluish surface resembling articular cartilage (Figs. 5 and 6).

Histological examination of sections taken vertically through the head of the femur under the vitallium cup showed cancellous bone with marrow interspaces. The bone terminated in a fairly regular line of ossification merging into cartilage which consisted of an eosinophilic matrix with groups of definite cartilage cells (Figs. 7 to 9). This merged imperceptibly into an articular surface layer where the cells were elongated and parallel to the articular surface. A few cells of stouter type were found in the surface layer. It seemed that there had been replacement of the cartilage after trimming of the head of the femur at operation.

Sections from the rim of the acetabulum (Fig. 10) showed synovial surface tissue at the border merging into articular cartilage with a dense eosinophilic fibrous and muscle base. The cartilage cells along the surface were typical of articular cartilage with paired nuclei.

COMMENT

In both cases, the articular cartilage covering the head of the femur was removed entirely. In the first case, the patient was an obese elderly woman in poor physical condition. Not much use was made of the arthroplasty; the chief benefit to the patient had been relief from pain. In conformity with this small amount of activity we found no cartilage formed over the head of the femur but only fibrous tissue, which was, in places, unhealthy. In marked contrast, the newly formed joint had been used by the second patient freely and constantly for more than three and a half years. In his case the head of the femur was covered by true articular cartilage, with healthy bone underneath and a smooth articular surface.

The two specimens illustrated seem to demonstrate that tissue form and cellular type correspond to functional demand, and that for the reproduction of articular cartilage, compression plus gliding movement are a necessary combined stimulus.

* A motion picture of this patient was shown at the combined meeting of the American, British and Canadian Orthopaedic Associations in Quebec in 1948.

A NEW WALKING-AID FOR SPASTIC PARALYSIS *

JOHN CHARNLEY, MANCHESTER, ENGLAND

The device is essentially a tubular frame with four legs which can be made to creep forward, in intermittent steps, by alternately depressing and raising the handles. When making a forward step the patient leans his body-weight on the handles and the leading pair of legs then slide forward through a maximum stride of seven inches (Fig. 1). In this position the apparatus is rigid and motionless and the patient is able to follow it with confidence, knowing that it will not run away from him or let him lose his balance. Having made a step forward to meet the apparatus, he now leans back and takes his weight off the

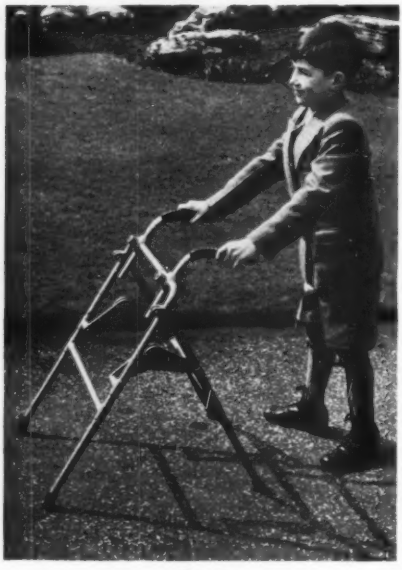


FIG. 1

FIG. 2

handles thereby allowing the rear pair of legs automatically to creep towards the leading legs (Fig. 2). In this new position the apparatus again becomes rigid and stable, and the patient is able again to recover his balance and confidence before making another forward step.

The appliance is made in two sizes, one for children and one for adults. It has easily adjustable handles which can be set at different heights, or in different positions, by releasing a spring catch, so that different patients can share its use. The aid is capable of negotiating a single step, either going up or going down. It will not negotiate a continuous flight of stairs unless each tread is wide enough to accommodate the legs of the apparatus in the fully extended position.

* The aid and the patient using it were demonstrated to the British Orthopaedic Association in Cardiff at the Spring 1950 meeting of the Association.

Mr W. C. Robb, the inventor of the appliance, was stimulated to attempt this solution of the problem by himself being the father of a spastic child.* When first seen by the writer, the child was five and a half years old. At that time, before the appliance had been invented, he was unable to make a single step without support; in this state he presented a whole-time occupation for both parents. But within a few days of experimenting with the appliance the child was able to roam about without assistance, thereby lifting from the mother an enormous burden of mental worry and physical hard work. The parents volunteered the opinion that since the child had been able to satisfy his curiosity about conditions inside and round the house his mental state had noticeably improved. He is now seven years old and is starting to take a few steps with the aid of two walking-sticks, though this still demands absolute concentration and with sticks he is not yet able to make more than a dozen consecutive steps without becoming fatigued and wildly erratic in his movements. With the walking-aid, however, he is now able to go to school, a distance of nearly one mile, and if he abandons the true walking gait (which he is not encouraged to do) he can progress at an astonishing speed by jumping with both legs together.

DISCUSSION

(*Contributed after the original reading of the paper*)

Miss M. Forrester-Brown said that the appliance seemed to be a development of a simple device consisting of two walking-sticks rigidly joined together and which she had seen in use at Putti's clinic in Bologna. The sticks themselves should be rigid and should diverge slightly at their lower ends; they should not be higher than the patient's elbows, so that he could lean down on them and use them as two " fore-legs." She had used Putti's method for over twenty years and had found it most valuable. This device was very convenient for most spastics and occupied little space when not in use.

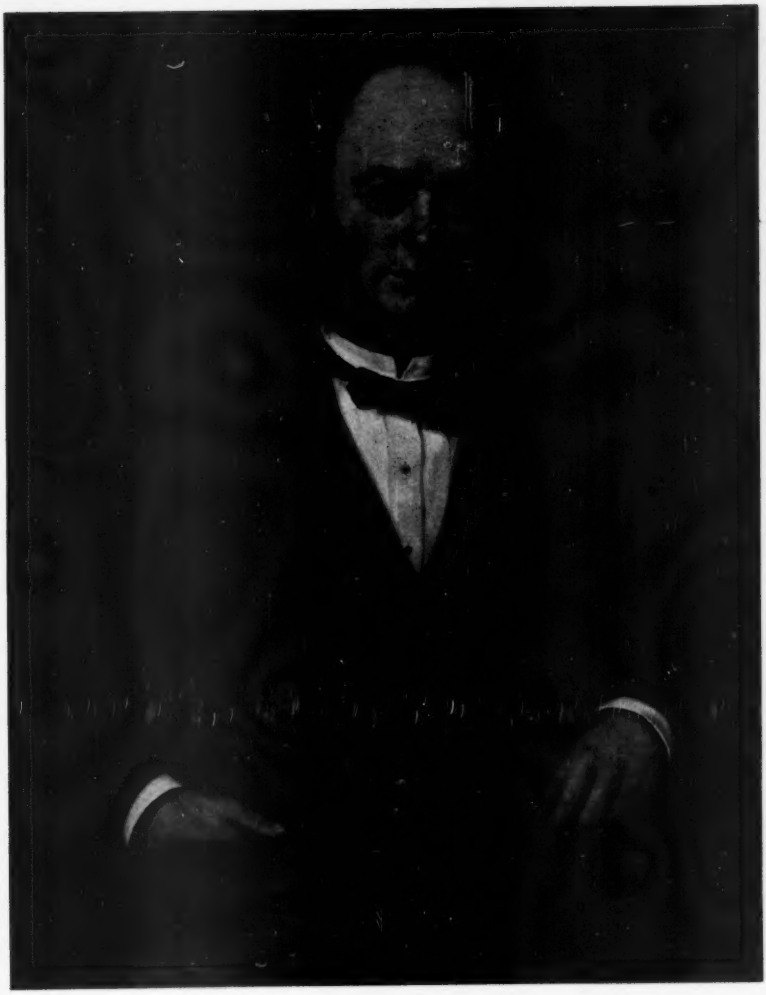
* Mr W. C. Robb of 503 Barton Road, Stretford, Manchester, who is marketing the device, will be pleased to answer any inquiries.

William Adams

A century has passed since William Adams began the study of orthopaedic surgery, in the development of which he played so outstanding a part. His attention was first directed to it by his great teacher, J. H. Green, F.R.S., the philosophical surgeon of St Thomas's Hospital, who believed " that Orthopaedy, as a new and special branch of study, in which not only the various forms of club-foot, but all the other deformities and malformations of the body were included as a group, opened up a wide field for pathological investigation and usefulness." Influenced by this belief in the expansive nature of orthopaedy, Adams in 1851 was encouraged to apply for the post of surgeon to the Royal Orthopaedic Hospital and was successful.

He was born on February 1, 1820, son of James Adams, L.S.A., of 39 Finsbury Square. In 1838 he entered the medical school of St Thomas's Hospital, of which hospital his father was Governor; but he studied anatomy and physiology at Webb Street School, Southwark, then under the management of Richard Grainger, younger brother of the founder. In 1842 the hospital obtained control of this school, retaining Grainger as demonstrator of physiology, and appointed Adams, who that year had become a Member of the Royal College of Surgeons, curator of the museum and demonstrator of morbid anatomy. He occupied this post for twelve years, during which in 1846 he joined with others in founding the Pathological Society of London. He became a Fellow of the Royal College of Surgeons in 1851 and three years later gave up his curatorship on appointment to the Grosvenor Place Medical School, adjoining St George's Hospital. Here he lectured on surgery and hospital practice, and delivered special courses of lectures on orthopaedic surgery—Thomas Spencer Wells was a fellow lecturer. After his election to the Royal Orthopaedic Hospital he was appointed surgeon to the Great Northern Hospital (now the Royal Northern Hospital) and to the National Hospital for the Paralysed and Epileptic.

Adams began as a general surgeon but his association with the Royal Orthopaedic Hospital, within a dozen years of its foundation, coupled with the influence of W. J. Little's teaching, aroused in him so absorbing an interest in the problem of crippling that his practice became almost confined to the treatment of deformities. He was well trained for the investigation of disabilities of the human frame, for he had spent a long apprenticeship at a pathological museum in the study of morbid anatomy. This scientific discipline coloured his every approach to any problem of deformity and is manifest in most of his contributions to orthopaedic surgery. In 1855 he began his researches on the repair of tendons, an inquiry which had already attracted the attention of Hunter and Paget, each of whom had carried out a good deal of experimental work in connection with it. Adams approached the subject afresh and communicated the results in papers to the *Transactions* of the Medical and Chirurgical and of the Pathological Societies, which he expanded to form a monograph entitled " On the Reparative Process in Human Tendons," published in 1860. The Achilles tendons were divided in sixteen rabbits at different dates and the parts were removed from the second to the sixty-second day after tenotomy. The process of tendon repair in the rabbit was also compared with that occurring in man. Adams was the first to observe the nature of human repair in a series of patients. During a period of nine years at the Royal Orthopaedic Hospital he was able to examine in the recent state fifteen patients in whom subcutaneous tenotomy had been performed at periods ranging from four days to three years previously, the patients having died from various causes unconnected with the operation of tenotomy. His investigations upon animal repair confirmed the account given by Paget of the development of new connective tissue, between the ends of the severed tendon, from a proper reparative



William Adams
1820-1900

material effused for the purpose and described as " nucleated blastema." Paget believed the sheath played no part in the restoration whereas Adams considered it of primary importance in maintaining a direct connection between the divided ends of the tendon, and that " the new reparative material was infiltrated between the fibrous elements of the sheath which, therefore, at once formed the matrix for the newly formed tendon, and also determined its direction and definite form." From the blastema a solid bond of union was formed between the ends of the tendon; it was tough, homogeneous rather than fibrous, and had a greyish translucent appearance which at once distinguished the new from the old tendon. The same process occurred in human beings except that the reparative material was formed more slowly and more sparingly just as callus was more abundant in bone repair in animals than in man.

Adams was constrained to inquire about the nature of repair of divided tendons, for tenotomy apart from manipulation was the only means of correcting deformity. Furthermore, subcutaneous cutting was all important; skin puncture admitted the minimum of air to the tissues. Many surgeons of the pre-antiseptic era were much concerned to keep air out of operation wounds for it was believed to have a mysterious property of promoting inflammation and suppuration, an evil, Hunter observed, from which subcutaneous surgery was free. Even Lister with complete knowledge still paid deference, with his carbolic spray, to the contaminating power of the air, nor indeed does a surgeon to-day feel that he can neglect such a menace, for the face mask and the meticulous care of the operating theatre, its corners and the manner of its ventilation, reveal an implicit fear of airborne infection.

The disability for which tenotomy was most frequently performed was club foot, a deformity which Adams studied exhaustively. In 1864 he was awarded the Jacksonian Prize of the Royal College of Surgeons for an essay on " Club Foot, its causes, pathology and treatment "; it was the result of a dozen years of careful observation and recording. The work was published as a monograph in 1866 and was much enlarged in the second edition of 1873. It was the most authoritative contribution on club foot since W. J. Little's classic of 1839. A very interesting account is given of the history of tenotomy up to Stromeyer. As for the cause of deformity he rejected the mechanical theory of external pressure during intra-uterine life; he considered the disability as one of intrinsic origin and favoured Little's view that the varus position of the foot was due to the spasmodic pull of certain muscles; but he did not attribute this abnormal muscle action to any organic disturbance of the central nervous system. Adams remarked upon the paucity of available pathological material for study yet he was able to dissect a number of young and adult specimens of the deformity and thereby contributed greatly to the better understanding of the pathology of club-foot. He was the first to report upon the microscopical examination of degenerated muscles involved in the deformity. With regard to the tarsal bones he found that " the os calcis and astragalus each occupy an oblique and, in severe cases, almost a vertical position . . . the astragalus is materially altered in form as well as in position; its neck passes obliquely inwards; and the articular surface of the head of this bone, instead of looking directly forwards, is turned towards the inner malleolus, and has therefore an antero-lateral aspect. . . . The navicular bone is displaced and drawn upwards and inwards, so far as to come in contact with the inner malleolus and holds a lateral relation with respect to the head and neck of the astragalus. . . . There appears to be sufficient evidence for believing that the malformed condition of the astragalus is determined by the malposition of two of the bones with which it articulates, viz., the navicular bone and the os calcis; and that its altered form is in evident adaptation to the altered position of these bones. . . . The astragalus in its cartilaginous state, having only an osseous centre, would mould itself during the latter part of its intra-uterine growth, to the lateral position of the navicular bone, and to the elevated position of the os calcis. The altered form of the astragalus, therefore, I regard as the result, rather than the cause, of the deformity. Cartilage has been, in my dissections, constantly found in those

portions of the articular surfaces of the astragalus which have either been extruded from, or may never have entered into, the composition of the ankle joint. . . . Cartilage has also, in every instance, been found on the exposed outer portion of the head of the astragalus. These facts sufficiently evince the tendency of the astragalus to develop itself in accordance with its normal typical form. The possibility of perfectly restoring the functions of the ankle joint, and the astragalo-navicular joints, is also proved, at least as far as the bones and their articular surfaces are concerned, if their normal relative position be restored at an early period. If this be accomplished we may consequently infer that the astragalus, during the subsequent period of its growth and ossification, will gradually assume its natural form. On the other hand, there can be little doubt that the difficulty of restoring the functions of the joints, into the composition of which the astragalus enters, would increase in direct proportion to the extent to which ossification of this bone has been allowed to proceed in the deformed position."

In the treatment of club foot he relied on manipulation and splinting alone or upon manipulation with tenotomy. If elevation of the os calcis continued the tendo Achillis was cut; also the tibialis anticus if inversion persisted. " But if, when the foot is everted by the pressure of the hand, the inner malleolus does not become sufficiently prominent, we must assume that the navicular bone is drawn towards the malleolus by the contraction of the tibialis posticus muscle and this tendon should also be divided." Occasionally the deltoid ligament was cut. Adams knew full well the intimate nature of all that impeded the correction of what was often a stubborn deformity. But he was only permitted to feel his way cautiously and work blindly in any attempt to sever tibialis posticus and deltoid ligament; his more fortunate successors at the same hospital, Elmslie, Trethowan and Brockman, were under no such restraint when boldly evolving the so-called soft-tissue operation. The splint he used as an aid to correction was the Scarpa shoe with ingenious improvements of his own. There was a metal calf trough to which was attached a steel bar proceeding along the inner side of the leg as far as the lower border of the heel, at which point it was fused, at a right angle, to a sole plate which itself was divided into two parts, opposite the transverse metatarsal joint, with a connecting metal strip bearing on its lower surface three joints individually controlled by a key. There were two similar joints interposed in the leg bar opposite the ankle. The leg and foot were bound to the splint by leather straps; a well-padded chamois leather skate strap passing across the front of the ankle kept the heel down on the sole plate. The controllable joints of the appliance enabled the foot to be dorsiflexed, plantar flexed, inverted or everted and the same variety of movement could be separately repeated at the transverse metatarsal joint with the addition of abduction or adduction of the forefoot. It was an admirable splint for its purpose but required daily skilled adjustment and was therefore essentially an appliance for in-patients. With the expansion of orthopaedic surgery and the introduction of open operative correction of deformities in general the pressure on beds increased, thus greatly reducing the number of patients who could be treated in hospital by splinting alone, and as the splint was unsuitable for an out-patient it gradually disappeared from use, but it lingered on at the Royal National Orthopaedic Hospital until the outbreak of the first world war.

The design of the splint and the placing of the two sets of joints were in conformity with his practice of dividing the treatment of club foot into two stages. The first stage was occupied in overcoming the inversion and adduction of the foot; when this was accomplished and the child was able to hold the foot in a straight line with the leg the second stage began with correction of the equinus element of the deformity and if necessary tenotomy of the tendo Achillis; but the fixation of the os calcis by this tendon was of great advantage in the first stage.

Subcutaneous surgery—Adams extended the application of subcutaneous surgery as widely as possible. He was the first in England to adopt this method as the routine procedure in the treatment of Dupuytren's contracture and of congenital wry-neck. He used a tenotome

with a small blade; in the hand he made multiple subcutaneous divisions of the palmar fascia and of its digital prolongations. The fingers were subsequently kept straight by his specially designed hand splint. In torticollis the tenotome was introduced just above the clavicle and the sternomastoid muscle cut from behind in a forward direction. The after-treatment consisted in stretching the neck in a head extension apparatus, the wearing of a hard felt jacket by day and a felt collar at night.

Subcutaneous osteotomy—Adams was perhaps the first to perform subcutaneous osteotomy in England—a type of operation introduced by Langenbeck in 1852—when by this method he corrected flexion ankylosis of the right hip joint in a man aged twenty-four years by cutting the neck of the femur. He had really planned to produce a pseudo-arthrosis but lacked a suitable cutting instrument capable of penetrating the skin through a tiny incision. After many trials on bones and hard woods a saw, small and strong with a wide double cutting edge carried at the end of a three-inch slender shank, was produced by Blaise. The operation was performed at the Great Northern Hospital on December 1, 1869. He "entered the tenotomy knife a little above the top of the great trochanter and carrying it straight down to the neck of the thigh bone divided the muscles and opened the capsular ligament freely. Withdrawing the knife I carried the small saw along the track made—preserving this by pressure of the finger—straight down to the bone and sawed through it from before backwards." Tenotomy of some contracted muscles was necessary before the hip could be completely straightened. A long interrupted Liston splint was applied to the limb. " In a fortnight I began to encourage motion but all attempts at movements were so painful that I gave up the idea and the result was bony anchylosis in a straight position with a good useful leg." This operation by Adams attracted widespread attention and was soon repeated by many surgeons. He himself adopted the same method in correcting malunited fractures of long bones and of severe rachitic deformities. Ogston and Macewen by subcutaneous cutting began to cure knock-knee; it was the procedure followed by F. J. Gant in his extra-articular subtrochanteric operation for flexion ankylosis of the hip which he first performed on December 10, 1872, when Adams was present.

Spinal curvature—Adams devoted much time to the study of spinal curvature in all its forms and particularly the pathology. He published a considerable volume on the subject in 1864 which was enlarged in the second edition of 1882. He remarked upon its preponderance in females and its frequency on the right side in the dorsal region. He divided the patients into three classes according to the pathology of their curvatures: physiological curves, commencing structural curves and confirmed structural curves. The first group exhibited no vertebral changes and were due to muscular weakness or faulty posture. In the second group the intervertebral cartilage only had suffered from unequal lateral pressure but with no vertebral changes. He laid great stress on the importance of being able to diagnose this class. The third group were those in which the intervertebral cartilages, the bodies of the vertebrae and the oblique articulating processes had all undergone structural changes and become adapted to the particular form of curvature produced by rotation of the bodies of the vertebrae.

He emphasized the fact that diagnostic signs carefully observed declared the nature of the underlying pathology. " It should always be borne in mind that the first evidence we have of any deviation in direction of the spinal column is not that of lateral curvature as judged of by any lateral deviation of the apices of the spinous processes; but the indications are those of horizontal rotation of the bodies of the vertebrae. According to my observation horizontal rotation of the bodies of the vertebrae always precedes lateral curvature, as indicated by the fixed lateral deviation of the apices of the spinous processes. . . . In the diagnosis of lateral curvature of the spine it is therefore a great fact, and one that should be strongly impressed on the mind, that we cannot rely exclusively upon the relative position of the apices of the spinous processes. . . . It is true that lateral deviation of the apices of the

spinous processes generally occurs both in slight and severe cases though not to an extent corresponding to the internal deviation of the bodies of the vertebrae. . . . When rotation of the bodies of the vertebrae has taken place, in however slight a degree, the patient cannot stoop in a direct line and at the same time preserve the symmetrical form of the back. If rotation of the bodies of the vertebrae has occurred the patient will always stoop in the oblique direction and the angles of the ribs will be observed to project posteriorly, and give a general prominence or fullness on the corresponding side; whilst on the opposite side a flattening—in slight cases not amounting to a depression—will be observed. The spine will also bend or curve forwards with less regularity through the region affected so that it appears less flexible at this part and remains straighter. These indications, when present, will form a valuable aid to the diagnosis of internal curvature in an early stage." With regard to treatment he relied upon a combination of partial recumbency, gymnastic exercises and mechanical support together with improvement of the general health by nutrition and medical means. The physiological curve was straightened without mechanical support. The second class of curve often required an appliance and sometimes a cure was achieved. The third class with severe curvature and well-established changes in the vertebrae was incurable. These patients might be improved but they were dependent upon mechanical support to prevent regression. The final model of spinal support, designed by Adams, and made by Ernst of light well-tempered steel, with arm crutches, adjustable spring plates over the rotated ribs, and fitting comfortably, is still unsurpassed after more than seventy years since its emergence.

Congenital dislocation of the hip—Adams was familiar with congenital dislocation of the hip. At the Section of Surgery at the annual meeting of the British Medical Association held in Cardiff in 1885 he opened a discussion on this disorder based on an experience of sixty patients, all of whom he had carefully studied; forty-seven were females and thirteen males; forty-one unilateral and nineteen bilateral. He regarded it as essentially a defect of the acetabulum. During the discussion Professor Bennett of Dublin exhibited a dissected pelvis of a girl aged six years with congenital dislocation of both hips. Adams had been able to reduce the dislocation in some patients by gradual traction, a method that Buckminster Brown had revived after it had been discarded since its introduction by Pravaz in 1838. Traction receded again upon Paci's dramatic demonstration of manipulative reduction in 1894 only to be revived in another form, by means of the abduction frame, during this last decade. Adams, however, failed to maintain the reduction of the dislocation until stability was established and was therefore disposed to regard the disorder as incurable.

Adams practised at No. 5 Henrietta Street, Cavendish Square, where now stands the Royal College of Nursing. In 1869 he delivered the Lettsomian Lectures on Rheumatic and Strumous Diseases of the Joints. In 1876 he was elected President of the Medical Society of London and in September of the same year he, Lauder Brunton and Richard Davy represented the Society at the International Medical Congress at Philadelphia at which he read a paper on his subcutaneous operation for dividing the neck of the femur. With Lister he watched Sayre excise the hip joint in a boy aged about ten years. The Cunarder *Scythia* took ten days on the outward passage in calm weather. Adams and his colleagues were loud in their praise of the reception and unbounded hospitality they received in America. He himself in private was hospitable, genial, humorous, a great talker with a soft voice and well-marked lisp. In 1895 he was elected an honorary member of the American Orthopaedic Association. The following year he retired from practice and went to live at No. 7 London Road, St John's Wood. He had married Mary Ann Mills in 1847 and had two sons and a daughter. He died on February 3, 1900, soon after his eightieth birthday.

William Adams was the best-known orthopaedic surgeon of his time in England. He came to the Royal Orthopaedic Hospital on the heels of W. J. Little who virtually trained him. He held the advantage over his teacher in that he was solely devoted to surgery and was a well-disciplined pathologist of great experience. It is doubtful whether there ever was

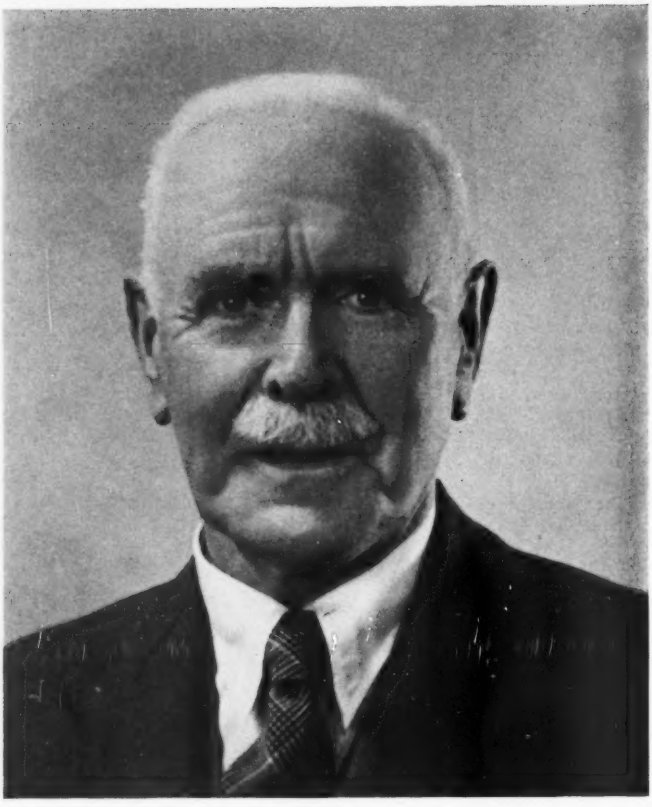
an orthopaedic surgeon better equipped to probe the problem of deformity on a scientific basis. With great energy he investigated the whole field of deformity and wrote more extensively upon it than anyone else; what he wrote bears the impress of first-hand knowledge and research. In interpreting his clinical observations he sought as far as possible to ascertain the underlying pathology, often comparing them with the clinical signs of a known morbid anatomy. He was particularly free from prejudices and his judgments were well balanced. Early in his career he lectured regularly on orthopaedic surgery and advocated a greater diffusion of its knowledge by the establishment of wards in general hospitals for this special branch of surgery. No one contributed more than William Adams to the advancement of orthopaedic surgery in the last century. His passing closed an epoch; it was the end of the tenotomy period, for he was older than Lister and never saw antiseptic surgery in its perfection.

ARTHUR ROCYN JONES.

We are grateful to the Royal National Orthopaedic Hospital for permission to reproduce the portrait of William Adams.

REFERENCES

ADAMS, W. (1860): On the Reparative Process in Human Tendons. London: J. Churchill.
ADAMS, W. (1871): A New Operation for Bony Anchylosis of the Hip Joint. London: J. & A. Churchill.
ADAMS, W. (1873): Club-Foot. Second edition. London: J. & A. Churchill.
ADAMS, W. (1882): Lectures on the Pathology and Treatment of Lateral and Other Forms of Curvature of the Spine. Second edition. London: J. & A. Churchill.
ADAMS, W. (1893): Post-Graduate Lectures on the Surgical Treatment of Deformities. London: Baillière, Tindall and Cox.
British Medical Journal (1885): **ii**, 859.
Lancet (1900): **i**, 812.
Plarr's Lives of the Fellows of the Royal College of Surgeons of England (1930): **1**, 7.
Proceedings of the Medical Society of London (1876): **3**, 97.



GATHORNE ROBERT GIRDLESTONE
1881-1950

The death of G. R. Girdlestone on December 30, 1950, has robbed British orthopaedics of yet another of that distinguished group of men who were the disciples of Robert Jones.

Gathorne Robert Girdlestone was the son of the Rev. R. B. Girdlestone, Honorary Canon of Christ Church, Oxford. He was born in 1881 and was educated at Charterhouse, at New College, Oxford, and at St Thomas's Hospital. After his house appointments at St Thomas's he settled in Shropshire at Oswestry and there came under the influence of Sir Robert Jones, an influence that was destined to shape the whole of his career. From Robert Jones and Agnes Hunt he learned—in the hospital that was later named after them—that orthopaedics was much more than a branch of surgery. The orthopaedic hospital was to be not merely a place to which patients came to seek relief but rather a centre from which workers went out into neighbouring towns, villages and hamlets to discover those who were too far away, poor,

ignorant or apathetic, to seek treatment for themselves or for their afflicted children. Diagnosis and treatment of established complaints was the first objective, but the ultimate aim was the detection and arrest of crippling conditions before deformity or other serious disability had had time to develop. It was some years before Girdlestone was able to apply what he had learned from these two great pioneers; but he had a profound conviction of his mission, and when the time came he rose rapidly to a unique position in British orthopaedics. He was the great missionary of regional orthopaedics with its central orthopaedic hospital, satellite clinics and unified staff.

During the first world war he was prevented from serving overseas by the effects of a serious chest injury, the result of a motor cycle accident. However, he was placed in charge of the orthopaedic division of a military hospital in Oxford which rapidly developed until there were some 400 beds under his care. At this time the Wingfield Convalescent Home was an old-fashioned institution in the neighbouring village of Headington; thanks to Robert Jones, Girdlestone was later able to take charge of some army huts which were erected in the grounds of this convalescent home. In 1919 the Wingfield Hospital, to give it its new name, came under the Ministry of Pensions, but provision was made for crippled children to be treated in one of its wards. In 1922 the whole hospital was transferred by the Ministry to the Wingfield Committee and Girdlestone was thus provided with the instrument which, until the end of his life, he wielded with such astonishing success.

Immediately after the war Robert Jones and his staunch disciple launched their campaign for the establishment of regional orthopaedic services, and in 1920 they organised the Central Council for the Care of Cripples of which Girdlestone was for some time joint honorary secretary. By 1925 his own experience in the three counties of Oxfordshire, Berkshire and Buckinghamshire was such that he was able to write with authority on how a regional scheme should be run, and it is significant that twenty years later, when the writer had occasion to correspond with people in certain colonial territories who were interested in orthopaedics, he found it expedient to lay hands on the few remaining copies of Girdlestone's monograph and send them overseas with the advice that no better guidance was obtainable anywhere. Girdlestone's appointment to the staffs of most of the general hospitals in the region—the Radcliffe Infirmary being the most important—and his establishment of clinics in smaller centres, enabled him to build up so complete a service that the benefits of orthopaedic surgery were available to almost everybody in the region. The work was done by the Wingfield staff, and permanent copies of all case notes were filed at the hospital. It was the Oswestry scheme all over again but with everyone concerned working full time and under one head. In this great undertaking he was loyally assisted by W. B. Foley, J. C. Scott and a number of other able men who worked with him for longer or shorter periods. In addition to this strong central administration there was also a very clear direction of therapeutic policy, and the team worked on well-defined lines which became more widely known as a result of the many papers that Girdlestone contributed to the literature of orthopaedics.

He was not only an outstanding organiser but a surgeon of great dexterity. His operations for Pott's paraplegia, hallux valgus, osteoarthritis of the hip and claw toes were particularly valuable contributions. Girdlestone was always interested in operative technique and every detail was worked out with extraordinary thoroughness. It was a healthy discipline and, after a time, a pleasure to work in his well-run theatres. In his endeavours to eliminate infection at operation no possible factor escaped examination; he enlisted the aid of R. B. Bourdillon in determining the part played by aerial contamination and the results of that work will undoubtedly have a profound influence on the question of the ventilation of operating theatres.

In 1930 Lord Nuffield (Sir William Morris, as he then was) became attracted by Girdlestone's work and through the generous aid of that great benefactor the old huts were replaced by modern buildings which incorporated features over which Girdlestone had

pondered so carefully and for so long. It was Girdlestone who encouraged Lord Nuffield to interest himself still further in British medicine, with results that are now well known. The Oxford Medical School benefited to the extent of two million pounds. In 1937, at Lord Nuffield's request, Girdlestone visited South Africa to prepare a scheme for the development of orthopaedic surgery in that vast Dominion; and the national Council for the Care of Cripples in South Africa was the result of this visit. In the same year Girdlestone was appointed Nuffield Professor of Orthopaedic Surgery, this being the first chair in the subject in the British Empire. He resigned this appointment at the beginning of the second war and devoted himself to more urgent work; he was a regional orthopaedic consultant in the Emergency Medical Service and honorary consultant to the Army and to the Ministry of Pensions. In 1942 he was elected President of the British Orthopaedic Association; in 1948 he applied his unparalleled experience to the formulation of a plan for regional orthopaedic and accident services within the framework of the new National Health Service; and in 1949 he achieved the integration of all the activities coming under the heading of orthopaedics in the Oxford region in what was called the Nuffield Orthopaedic Centre, which was endowed by Lord Nuffield with a sum of £50,000. This was the corner-stone of the edifice to which he had dedicated his life.

A catalogue of his achievements, even a complete one, would, however, be an imperfect tribute; the character of the man himself was no less remarkable. Girdlestone had all the charm, the piety and some of the haughty individualism of an Elizabethan. He was a devout Christian and his patients knew it; when professional skill had reached its limits his sympathy and concern for their future gave fresh confidence and hope to those who were permanently disabled. Yet his belief in his mission was so intense that he sometimes alienated those whose ideas did not correspond precisely with his own. In pursuing any scheme on which he had set his heart he was indefatigable and quite fearless; he was no trimmer. But for his insistence there would have been no chair of orthopaedic surgery at Oxford; yet he sought it not for himself but only for the advancement of orthopaedics. Oxford owes the Churchill Hospital to Girdlestone's efforts; the obstacles to this achievement would have broken the spirit of many men. It was he who was chiefly responsible for installing that gallant little company of American surgeons who formed what was called the American Hospital in Britain in this new hospital, with buildings and facilities that, for the time being, they could call their own. There were occasions in the affairs of the Wingfield when his committee, devoted to him as they were, had to tell him that there was no money for some addition that he wanted; on more than one occasion his answer was that he would pay for it himself—and he did.

The hospital was an extension of his home life which was made idyllically happy by his wife Ina. They had no children—their family life was the Wingfield. At a few minutes before nine (half-past eight for operations) Girdlestone's handsome upright figure appeared on the path between his house and the hospital, and the place sprang to its ordered life like an orchestra under the baton of a conductor. He knew all the older members of the staff by name, he had a friendly word for everyone (sometimes one of fatherly reproof) and there were many who at one time or another had been helped by him in some serious personal difficulty. He was not a philanthropist in the ordinary sense; his horizon was not a wide one; he was not a member of societies for improving this and that. But in his chosen sphere his intense zeal was matched by his generosity. There were occasions when someone connected with the Wingfield was in need of money, and more than a small sum. The usual deliberations provided no solution. Then Girdlestone would say that he was trustee of a fund that could be drawn on in such circumstances and that the matter could be left to him. The source of the fund was never disclosed; it was sometimes suspected that he sought help from Lord Nuffield, but it was a nearer guess that he himself provided the money. It was not, therefore, surprising that the hospital had an esprit de corps that was apparent even to the casual visitor. Girdlestone used to refer very frequently to the Wingfield spirit—it sometimes became

rather an old joke—but it was a very real thing, an influence that made for happiness and good work, and it was felt throughout the region.

There is a tendency, a natural and a proper one, for eminent men gradually to enlarge their spheres of activity; it would be unfortunate if it were otherwise, for the State and our profession must be able to command the services of and receive guidance from men of exceptional intelligence and experience. The price to be paid for work in a wider field, and paid often with sorrow, is the abandonment of many local interests, which the passage of years and old associations have made peculiarly sweet. Girdlestone chose otherwise and for him the choice was right. He knew what he could do well and he stuck to it; in his own line of work he was as confident and superbly skilful as in the two games he played (he was outstanding at tennis and golf and reached the semi-finals in a competition at St Andrews only a few months before he died). He directed all his energies to the development of his hospital, his region, the scheme which they embodied, and the link he had forged with his university. His influence extended far and wide, but it was chiefly in virtue of what he did in Oxford. He taught by example rather than precept. And in these days when committees multiply endlessly, and when men with heavy clinical responsibilities are constantly tempted to dissipate their energies by serving on some august body or another, it is well to reflect on the achievements of a man who, if he had received the public recognition due to him, might well have chosen a parish pump as his device. H. J. S.

Girdlestone's entry into the field of orthopaedic surgery was an accident of circumstance. He had become a general practitioner surgeon in Shropshire and went to Baschurch first as a spectator and later to assist at operations. It was not long before his own natural pioneer spirit inspired by the work of those two great personalities, Agnes Hunt and Robert Jones, convinced him that orthopaedic surgery was to be his life work.

In appearance he was a striking figure—tall, handsome and with a beautiful voice. His many contributions to the literature of his subject were expressed in delightful prose; they bore the mark of wide reading and of a cultivated mind. He was also a devoted listener to classical music. He shared all these tastes with his wife in an idyllic partnership; but there was also another Girdlestone—a natural player of ball games, a golfer with a beautiful style which remained with him almost to the end. He won the Irish Amateur Championship after leaving Oxford and he might have gone far if his busy professional life had not claimed the larger part of his reserves of energy.

No memoir of this man of high quality—one of the most distinguished surgeons of his generation—would be complete without reference to the deep religious convictions which sustained him in all his work. This was a Girdlestone known to a host of witnesses. H. P.

PROCEEDINGS AND REPORTS OF UNIVERSITIES, COLLEGES, COUNCILS AND ASSOCIATIONS

GREAT BRITAIN

UNIVERSITY OF OXFORD

LECTURES AT THE NUFFIELD ORTHOPAEDIC CENTRE

Professor Trueta has invited several eminent authorities to lecture at the Oxford Orthopaedic Centre (Wingfield-Morris Hospital) on subjects illustrating various aspects of the function of the limbs. Among the lectures last year was one by *Professor J. H. Burn* on recent work on adrenaline and its related substance *nor*adrenaline under the title "Blood pressure and the suprarenal medulla."

Professor Burn described the discovery by von Euler* in 1948 of the non-methylated amine *nor*adrenaline, which is believed to be the precursor of adrenaline, in the tumours of the suprarenal medulla, the phaeochromocytomas. He gave an account of the pharmacology of *nor*adrenaline, which differs from adrenaline in that it has less effect upon blood sugar and in producing constriction of the vessels in muscle. Both adrenaline and *nor*adrenaline are liberated when the splanchnic nerves are stimulated, and it appears that an undue amount of *nor*adrenaline will act to a disadvantage in the animal's response to a crisis, if only because of the vaso-constriction in muscles. There is evidence that the transformation of *nor*adrenaline to adrenaline can be accelerated by a diet rich in methionine, and conversely, that a methionine deficiency leads to a lower proportion of adrenaline in the suprarenal medulla.

Figure 1 illustrates how *nor*adrenaline can be recognised by its very feeble action upon the innervated nictitating membrane of the cat. Its effect on the denervated nictitating membrane and on the blood-pressure shows barely any difference from that of adrenaline. Stimulation of the splanchnic nerve naturally leads to a combined effect, as both substances are released.

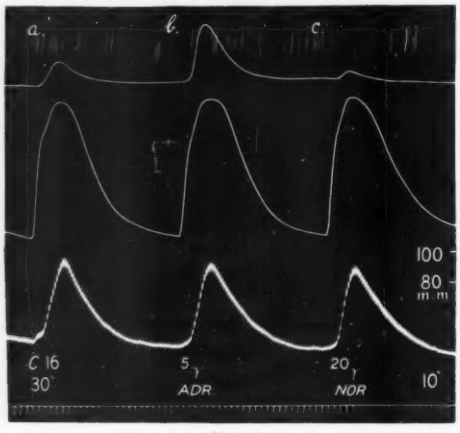


FIG. 1

Observations in a spinal cat which has been eviscerated. The upper record shows the contractions of the innervated nictitating membrane. The middle record shows the contractions of the denervated nictitating membrane. The lower record is of the blood pressure. At *a*, stimulation of the left splanchnic nerve liberates active substances from the medulla which produce a contraction of the innervated nictitating membrane intermediate in size between the contraction produced by intravenous adrenaline, *b*, and that produced by intravenous *nor*adrenaline, *c*.

* EULER, U. S. VON (1948): Acta Physiologica Scandinavica **16**, 63.

NEW GIRDLESTONE SCHOLARSHIP

Lord Nuffield has given £10,000 to the Nuffield Orthopaedic Centre, Oxford, for the purpose of creating a scholarship commemorating the late Gathorne Robert Girdlestone, M.A., M.D., F.R.C.S., founder of the Wingfield-Morris Orthopaedic Hospital and one-time Nuffield Professor of Orthopaedic Surgery in the University of Oxford.

Lord Nuffield, who has been associated for many years with the projects and endeavours of "G. R. G." and who a year ago gave £50,000 for the organisation of the Nuffield Orthopaedic Centre, wishes that the passing of this man who has done so much for orthopaedic surgery shall be marked by the creation of a Girdlestone Scholarship, which will be used to enable doctors from overseas to spend a period of time at the Wingfield-Morris Orthopaedic Hospital working within and learning from the organisation which he created and which so clearly bears the imprint of his personality. Details of the scholarship will be announced later.

UNIVERSITY OF LIVERPOOL

MASTER OF ORTHOPAEDIC SURGERY

Of the many surgeons from all parts of the world who, fifteen months ago, sought the opportunity of working in Liverpool for the higher degree of Master of Orthopaedic Surgery, nineteen fulfilled the preliminary requirements of sound basic training in general surgery, clinical experience in orthopaedic surgery and, in the case of graduates from this country, possession of a Fellowship of one of the Royal Colleges of Surgeons. During the year's course each candidate had to present a critical dissertation on a subject of his own choice and all were acceptable. Finally, in the recent examination, twelve candidates succeeded in reaching the very high academic as well as clinical standard that is now demanded. The successful graduates were:

N. J. Blockey, Manchester, England;
V. K. Drennan, Liverpool, England;
L. Henry, Cheltenham, England;
T. McSweeney, Cork, Ireland;
J. B. Maloney, Sydney, Australia;
A. M. Sallam, Alexandria, Egypt;
L. Bonnin, Adelaide, Australia;
K. S. Fan, Nanking, China;
J. H. Hicks, Cheltenham, England;
F. Machinik, Cape Town, South Africa;
M. R. Reddy, Hyderabad, India;
H. O. Williams, Willaston, England.

The examiners selected two candidates for special mention: Fan of Nanking for his consistently high standard, and N. J. Blockey, who by reason of his outstanding clinical ability was awarded the Directors' Prize.

The external examiners were, as in 1949, Mr R. I. Stirling of Edinburgh and Sir Reginald Watson-Jones of London.

REGIONAL ORTHOPAEDIC CLUBS

SOUTH-WEST ORTHOPAEDIC CLUB

The South-West Orthopaedic Club met at Mount Gold Orthopaedic Hospital, Plymouth, on November 25, 1950. Mr G. J. Lillie was in the chair. The morning session was devoted to short papers.

Dr Angell presented his experiences with chemical sympathectomy, outlining the indications and his method. A paravertebral block with 10 per cent phenol was employed. Dr Angell said that the procedure was simple and effective in the lumbar region, but was not to be advised in the neck because of the proximity of vital structures. *Dr O'Brien* discussed the differential diagnosis of multiple myeloma and senile osteoporosis. He outlined the radiological differences, but said that the main diagnosis depended on the results of sternal puncture or a punch biopsy of the spinous process of an affected vertebra, when the typical cells of multiple myelomatosis were seen. *Mr Lillie* reviewed the treatment of spinal instability, which he stated was the commonest cause of low back pain. The most important factor in maintaining spinal stability was normal muscle tone; once this was lost, the skeletal structures were strained. All treatment aimed at restoring stability of the spine, either by improving muscle tone or by supporting the spine and sacrificing mobility. Discussing treatment, he said that physiotherapy should be employed only in cases in which full co-operation by the patient was obtainable. There were only three indications for manipulation, namely: 1) backache that was improved by activity and made worse by rest; 2) residual backache after sciatica; and 3) acute prolapse of an intervertebral disc with severe symptoms, whilst under an anaesthetic prior to application of a plaster jacket. The main contra-indications were marked osteoarthritic changes in a radiograph and age exceeding forty-five years. Supports relieved the backache of most patients and were essential in: 1) obese, atonic,

unco-operative women; 2) heavy women with large families in bad housing conditions; 3) the elderly, unable to carry out remedial exercises; and 4) sufferers with grossly osteoarthritic spines.

Mr Salz reported the results of a follow-up investigation of sixty-four out of 216 patients operated on for spinal fusion at Mount Gold Hospital during the last sixteen years. The incidence of non-fusion or pseudarthrosis diagnosed after radiological examination was 25 per cent of the total. Fusion in the lumbo-sacral region is apparently difficult to achieve. He compared the Plymouth figures with those of Swift (1940)* and of Thompson and Ralston (1949).†

Dr Johnston, Medical Officer of Health for Plymouth, related his experiences at an isolation hospital admitting acute cases of poliomyelitis during the recent epidemic. *Dr Mason* described two interesting cases, one of acute anterior poliomyelitis occurring in a new-born infant. It must be inferred that infection occurred during birth, as the infant was apparently normal until he was a few days old, when flaccid paralysis developed. The second case was one of miliary tuberculosis in an infant whose mother had miliary tuberculosis. The infection occurred presumably *in utero*.

After lunch, cases were demonstrated by Mr Lillie, Mr Salz and the staff of Mount Gold Hospital. A visit was paid later to the Dame Hannah Rogers School for Cerebral Palsy at Ivybridge, and the work of the school was demonstrated by Miss Field (Principal) and the physiotherapy staff.

EAST ANGLIAN ORTHOPAEDIC CLUB

A meeting was held on November 25, 1950, at Addenbrooke's Hospital, Cambridge. The following were present: Messrs Bell Jones, Brittain, Butler, Fairbank, Howard, Jamieson, Keir, McKee, Martin, Noel Smith, and eight visitors including Dr Fell, Consultant in Physical Medicine to the United Cambridge Hospitals. Clinical cases were shown.

Cyst of fibula—*Mr Tennant*, introduced by Mr Butler, showed the case of a girl who had had a cyst at the lower end of the fibula. This had been treated by a slide graft, but a pseudarthrosis developed at the lower end. Later a fracture had occurred at the lower end of the tibia, where an abnormality was seen in some of the later films. After considerable discussion it was thought that this case was one of Albright's syndrome, without precocious puberty.

Pathological fracture of femur—Mr Tennant also showed a small boy with a fracture of the shaft of the femur, which was thin and short. At one point there had been local absorption of a segment of bone, for which no adequate explanation was found at operation. The attenuated and sclerosed bone was excised and the gap bridged by grafts. Discussion on the diagnosis produced a number of interesting opinions, but no agreement.

Arthrodesis of knee—*Mr McKee* and *Mr White* demonstrated a method of arthrodesis of the knee with staples inserted after the surfaces had been approximated by Charnley's apparatus, which was later removed. A transverse bone graft had sometimes been used in addition to the staples.

Other cases shown included osteitis of the pubis after an appendix abscess, with gradual spontaneous resolution (shown by *Mr Murray*); staphylococcal osteomyelitis of the clavicle occurring during an attack of scarlet fever (*Mr Echstein*); Charcot's arthropathy of the hip joint treated successfully by subtrochanteric displacement osteotomy (*Mr Jamieson*); and impaired growth of the fibula after osteomyelitis, with consequent malalignment of the ankle joint (*Mr Fairbank*).

A further meeting was held on January 27, 1951, at the East Suffolk and Ipswich Hospital, when the following were present: Messrs Bell Jones, Brittain, Butler, Fairbank, Howard, Jamieson, Martin, Noel Smith, and eight visitors.

Osteoclastoma—*Mr Kupfer*, introduced by Mr Bell Jones, showed a case of osteoclastoma in which the cavity continued to increase in size after curetting and packing with bone chips, which were quickly absorbed. Radiation therapy also failed to control the tumour, and amputation was ultimately resorted to. Despite the history of active growth, histological examination showed no evidence of malignant characteristics.

Spontaneous fracture of neck of femur—*Mr Marks* showed two patients with spontaneous fracture of the neck of the femur. One was a man with rheumatoid arthritis who felt a sudden severe pain in the hip and fell to the ground. He was able to walk home with difficulty and continued to get about with sticks. When he attended the hospital, a radiograph showed a transcervical fracture in good position. Since he was walking with reasonable comfort, he was allowed to continue to do so and serial radiographs suggested that union was progressing. The second patient was a

* SWIFT, W. E. (1940): Journal of Bone and Joint Surgery, **22–A, 815.**

† THOMPSON, W. A. L., RALSTON, E. L. (1949): Journal of Bone and Joint Surgery, **31–A,** 400.

man with old tuberculous disease of the spine. The fracture occurred while he was sitting at lunch. He was treated by a McMurray osteotomy which in later radiographs was shown to be firmly healed, though the fracture remained ununited.

In the discussion that followed some differing opinions were expressed. The suggestion that the fractures were stress fractures was not generally accepted. Several members maintained that the spontaneous fractures had occurred in bones that were osteoporotic from general disease.

Chronic osteomyelitis—*Mr Bell Jones* showed two patients with diffuse pain in the thigh. He showed a series of radiographs taken over several years in which thickening and irregular sclerosis of the femur were apparent round small areas of rarefaction. Biopsy had not helped in the diagnosis, but in one case incision into an area of tenderness revealed a subperiosteal abscess. Staphylococcus aureus was grown from the pus. Mr Bell Jones asked for discussion on the diagnosis. He suggested that these might be two cases of osteoid osteoma but the general feeling of the meeting was that they were both cases of chronic osteomyelitis of the Garré type.

Other cases shown included a child with dislocations of both hips and both knees (shown by *Miss Brash*); a ganglio-neuroma in the loin, in a young woman (*Mr Baxter*); and ischio-femoral arthrodesis of the hip (*Mr Brittain*).

The next meeting is to be held at the Norfolk and Norwich Hospital at the invitation of Mr H. A. Brittain.

THE LIVERPOOL REGIONAL ORTHOPAEDIC CLUB

The club's second, and very well attended, meeting was devoted to clinical demonstrations and discussion, and was held at the Liverpool Royal Infirmary on November 8, 1950. *Mr Norman Roberts* and *Mr Robert Roaf* demonstrated a group of patients on whom displacement osteotomies had been done; the discussion naturally centred mainly on the surgery of the stiff hip. Two groups of patients were then presented. In the one group arthrodesis of the wrist had been performed for osteoarthritis of the wrist after fracture of the scaphoid; in the other group the scaphoid had been excised.

Discussion was lively. Although it was probable that the conditions of the two sets of wrists were not properly comparable before operation, it was interesting that no difficulty had been encountered in obtaining a sound arthrodesis, provided (as *Mr Norman Roberts* said) that all articular cartilage was removed; he favoured iliac chip grafts as the "incentive."

Mr Robert Roaf showed two patients whose legs had been equalised by shortening the longer rather than by lengthening the shorter, and he suggested that the decision should rest with the patient who should in fact not be operated on until he was old enough to exercise discretion.

The problem of a low fracture of the olecranon with comminution of the proximal fragment and dislocation forwards of the radius and ulna was demonstrated by a series of patients in whom the results, so far as movement was concerned, were not very good. Metallic fixation of the two fragments had been impracticable because of the comminution. Subluxation had tended to occur in some cases and considerable limitation had resulted in others. It was thought (by *Mr B. L. McFarland*) that quite possibly some limitation of movement might be inevitable because of the damage to the elbow joint as a whole from the initial injury.

Mr Proctor demonstrated the advisability of open reduction and tibio-fibular fixation for lateral rotation fracture-dislocations of the ankle in which "diastasis" had occurred. Finally two cases of mid-tarsal amputation were shown; the second patient was an old lady who had lived a normal life for seventy-one years since her operation.

After the meeting Mr G. T. Partridge was elected chairman for the year 1951, and Mr J. P. Heron was re-elected secretary. The first Annual Dinner terminated an enjoyable and instructive session.

THE BONE AND TOOTH SOCIETY

The society held its second scientific meeting at the Eastman Dental Clinic, London, on October 3, 1950. This took the form of a symposium on "Tooth Structure," at which Dr E. W. Fish took the chair.

Professor E. B. Manley discussed histological investigations that had been carried out on human enamel, particularly in relation to dental caries. He described the technical difficulties encountered in the microscopic study of such a highly calcified structure, but was able to demonstrate the results both of conventional techniques and of a recently evolved method for preparing decalcified serial paraffin sections of mature enamel. *Mr Ivor R. H. Kramer* dealt specifically with the histological structure of dentine and described the collagenous matrix, the dentinal tubules, the odontoblast cells and their processes. "Neumann's sheath" and the question of dentine innervation were discussed. *Dr J. Thewlis* showed how X-ray crystallographic analysis

and investigation with the polarising microscope can be used to elucidate the structural chemistry and crystal orientation of enamel. In the discussion of these papers *Mr M. V. Stack* described some work on the organic constituents of dentine. He stated that collagen was the only important protein present (to the extent of 18 per cent) and was the main organic constituent; citric acid was the constituent of next importance (0·9 per cent). *Dr P. Pincus* described the isolation of a sulphated muco-polysaccharide from dentine and commented on the possibility of a relationship with dental caries. *Mr J. Smiles* described the application of phase-contrast microscopy to the investigation of tooth structure.

The third scientific meeting, held on December 5, 1950, at the Institute of Orthopaedics, took the form of a symposium on "Calcification of Bone," at which Professor S. L. Baker took the chair. *Professor G. H. Bell* opened by describing methods of measuring the breaking stress and the modulus of elasticity of bone. Various attempts had been made to change the properties of bony material by alteration of diet (vitamin D deficiency, calcium deficiency, or dietary excess of fluorine), by administration of various hormones (thyroid, parathyroid or ovarian), and by nerve section. Changes in chemical composition, together with elasticity, breaking stress and X-ray structure, were described under these various conditions. *Dr G. Bourne* gave a brief account of the factors affecting the histological structure of bone and the role of the various histological elements in bone repair. He discussed the relationship of phosphatase to bone formation from the histochemical standpoint, and the relations between the organic matrix and the deposition of calcium salts.

Radioactive isotope studies were described by *Mr G. Rigby-Jones*. He briefly reviewed the literature on quantitative experiments on absorption of radioactive calcium phosphorus and its assimilation by bone. Recent work on ionic interchange and recrystallisation of apatite crystals was discussed. Autoradiographs of bone were shown, and attention drawn to possible dangers of histochemography.

The chairman then called upon other speakers. *Dr R. Pearcy* gave data showing the effect of dietary calcium levels on the successive increase and decrease of the area of cross-section, and of the area/weight, of rat bones during gestation and lactation. Similar experiments in progress with sheep were mentioned, and a few radiographs demonstrating the erosion of sheep bones during lactation were shown. *Dr H. R. Perkins* described the connection between calcium metabolism and citric acid in the animal body and indicated how variations in blood citrate levels might influence the equilibrium between bone salt and the calcium of phosphate ions in the surrounding fluid. *Dr J. J. Pritchard* showed that areas of incipient ossification in the rabbit foetus indicate heavy glycogen deposition. Such deposition is present in the early stages of osteoblast development. During growth there is a conspicuous decrease in glycogen corresponding with the appearance of greatest alkaline phosphatase activity.

It was pointed out by *Dr J. Lorch* that osteoid seems to be a regular feature during membrane and cartilage bone formation in teleost fishes as well as chick embryos. There was no correlation between acid phosphatase and calcification, and methods for localisation of acid phosphatase appeared insufficiently reliable to define the position of the enzyme at the cellular level. *Dr C. H. G. Price* commented on the occurrence of high acid phosphatase content of bone tumours.

FRANCE

THE FRENCH SOCIETY OF ORTHOPAEDICS AND TRAUMATOLOGY

The twenty-fifth of the Society's annual meetings was held in Paris on October 6 and 7, 1950, with Professor Marcel Fèvre as president. Professor Fèvre entertained members and guests at a luncheon at the Hôpital des Enfants-Malades, Professor Ombredanne being in the chair.

In the scientific programme the first discussion, on lateral dislocation of the patella, was opened by *Drs Marie* (Lyons) and *Barcat* (Paris), who gave a full report on current views. *Professor Fèvre* exhibited a moving film of the operation—described by himself with Dr Dupuis—consisting of realignment of the patellar tendon and lateral transposition of part of the vastus medialis. Later speakers pointed out the advantages of excision of the patella in cases complicated by patello-femoral arthritis.

The second principal topic was opened by *Drs Gerard-Marchant* (Paris) and *Salmon* (Marseilles) who reviewed the present knowledge of antibiotics and chemotherapy in the treatment of tuberculosis of bones and joints, and analysed the end-results so far achieved. Among contributions on particular aspects of many other subjects there may be mentioned papers by *Drs J. Gosset* (Paris) and *Marino-Zuco* (Rome), on the treatment of subluxations of the hip by osteotomy; by *Drs Guilleminet* (Lyons) and *Herbert* (Aix-les-Bains) on the use of stored bone for grafts; by *Dr*

Lombard (Algiers) on Volkmann's contracture; and by *Professor Merle d'Aubigné* (Paris) on the operative treatment of spondylolisthesis by the trans-peritoneal approach.

Two new officers were elected: *Professor Étienne* (Montpellier), president; and *Drs Huc* (Paris) and *Ingelrans* (Lille), vice-presidents. The next Congress was arranged for October 1951. The principal topics will be: fractures involving the hip joint (excluding fractures of the neck of the femur), to be opened by *Drs Cauchoix* (Paris) and *Truchet* (Chambéry); and the treatment of unreduced congenital dislocation of the hip in adults, to be opened by *Drs Poilleux* (Paris) and *Creyssel* (Lyons). The main subjects for 1952 will be the treatment of congenital talipes equino-varus and the treatment of Dupuytren's contracture.

The *Journées Orthopédiques*, usually held in the spring, have been cancelled this year in favour of the meeting of the International Society in Stockholm.

REVUE FRANCAISE D'ORTHOPEDIE ET DE TRAUMATOLOGIE

The Editorial Committee of the *Revue* has decided that it shall in future appear in an enlarged form and under a new title, *Revue de Chirurgie Orthopédique et Réparatrice*. In taking this step the Committee has co-opted Drs J. Gosset, Paul Petit, Jean Cauchoix and P. Gerard-Marchant, and has decided to invite contributions from outside France.

DENMARK

DANISH ORTHOPAEDIC ASSOCIATION

Membership of the Danish Orthopaedic Association now includes fifteen active and fifty-three associated members. The president is Dr Sven Kiær (Copenhagen), and the honorary secretary Dr Eivind Thomasen (Arhus).

The 1950 autumn meeting of the Association took place at the Orthopaedic Hospital in Copenhagen on November 18 and 19. The main topic was vascular diseases.

Post-thrombotic sequelae in lower extremities and their treatment—*Dr Gunnar Bauer* (Mariestad, Sweden) had been invited to report on the results of his treatment of post-thrombotic disease of the leg by resection of the popliteal vein—a method now frequently used in Denmark. The speaker surveyed the pathology of the disease and stressed that the double-trunked vena fibularis was the primary seat of the thrombosis, which spread from there upwards in the superficial femoral vein. His retrograde phlebography—extensively used in his earlier series of cases—showed that a lumen in the femoral vein always recurred, and that the valves of the vein were gravely damaged. Histological examination of the resected popliteal vein proved that the destruction of the valves was the result of a previous thrombosis in one-half the cases in a series of 300. Of the other 150 cases most showed a damaged elastica (phlebosclerosis). In a few cases there was no histological evidence to account for the malfunctioning of the valves. The treatment was resection of a few centimetres of the popliteal vein; other neighbouring veins were ligated, and if an incompetent long saphenous vein was present a resection distal to the inguinal ligament was performed. Indications for operation were based on the typical picture of the post-thrombotic syndrome: pain, oedema, induration and ulcer—the last being present in four-fifths of the cases. Retrograde phlebography was done in doubtful cases, *i.e.*, mainly cases in which there was an incompetent long saphenous vein and in which there was doubt whether an incompetent femoral vein was not responsible for the symptoms. After resection of the long saphenous vein in such cases, the outcome of the retrograde phlebography performed in the central stump determined whether the popliteal vein should also be resected. Results in the series could not yet be judged, as the method was first used only four years ago. However, a follow-up of about 200 cases showed good results in 84 per cent; there was recurrence in 16 per cent of the cases—mainly because an incompetent long saphenous vein was not resected, but in some cases a superimposed arterial disease was thought to be responsible for continued pain, and a lumbar sympathectomy was performed. Dr Bauer ended his report by stressing the importance of treating these patients with the post-thrombotic syndrome. He estimated that about 35,000 (0·5 per cent) of the Swedish population were affected.

During the discussion, the value of Hojensgaard's and Sturup's measurement of the pressure in the vein was emphasized by Dr Knud Jansen (Copenhagen), as a method of determining which cases should be operated on. *Dr Arne Bertelsen* (Copenhagen) mentioned arterio-venous anastomoses as responsible for the same syndrome in many younger patients. Rapidly developing varicose veins and recurrent ulcers in adolescence always suggested arterio-venous anastomoses in the leg. *Dr Sven Kiær* suggested that the sympathectomy done on the vein when it is resected is of importance in creating a better venous return, particularly in cases with no recanalisation of the thrombotic occluded vena femoralis-iliaca.

Arterial and arterio-venous aneurysms—*Dr Sven Kiær* reported two operation cases of arterial aneurysm and discussed the various methods of treatment of such cases and cases of arterio-venous aneurysm. In discussion, *Drs Dan Prytz* (Copenhagen), *Arne Bertelsen* (Copenhagen) and *Kai Dohn* (Copenhagen) reviewed the literature of the problems of congenital arterio-venous anastomoses in the extremities and reported a typical case recently operated on. The symptoms were varicose veins, considerable lengthening of the extremity, and ulceration.

The conservative treatment of scoliosis—*Dr P. K. G. Bentzon* (Arhus) reported a follow-up made by *Dr Poul Lutken* (Alborg) of 406 cases of scoliosis. 7 per cent were definitely improved by conservative measures, 76 per cent were unchanged, and 17 per cent were made more or less worse. *Dr P. G. K. Bentzon* touched upon the problem whether it was proper to accept the modern form of treatment with spinal fusion to the extent now accepted in America and in several Scandinavian clinics.

Treatment of fractures of the calcaneum by early mobilisation without weight-bearing—*Drs Arne Bertelsen* and *Eivin Hasner* described a new method of treating fractures of the calcaneum by early mobilisation in a non-weight-bearing splint. (It was mentioned that *Roberts* of Liverpool had begun a similar treatment, and in a letter to Bertelsen had claimed that it was giving promising results in England.) Twenty-three cases had been treated and observed for 1 to 6 years. The results were very promising; the average duration of treatment had been sixty-two days and the average stay in hospital thirteen days; the period of incapacity for work had varied between two and seven months. The speakers pointed out that intra-articular fractures with dislocation were in a minority among the material, which, however, included all cases of fracture of the calcaneum treated at the University Clinic of Surgery, Copenhagen, during the period 1944–50.

AUSTRIA

AUSTRIAN ORTHOPAEDIC ASSOCIATION

The Austrian Orthopaedic Association (Vereiningung der Orthopäden Österreichs) was re-founded at an inaugural meeting at the end of 1948, when Professor Dr Ph. Erlacher, Vienna, was elected president. The association has since met regularly and has also organised joint meetings with the Viennese Society of Traumatology, the Austrian Society of Neurology, and the Austrian Society of Paediatry.

VIENNA ACCIDENT HOSPITAL

The Accident Hospital, Vienna (Surgeon-in-Chief, Professor Dr Lorenz Böhler) early this year celebrates the twenty-fifth anniversary of its foundation. To mark the occasion a Congress for Traumatic Surgery is being arranged for May 15 to 17, 1951. The programme falls into two parts: one will be devoted to the treatment of fractures of the neck of the femur and their sequelae (non-union and necrosis); the other part will consist of lectures on subjects of the speakers' own choice.

Intending visitors are asked to send their name and their address to Professor Dr Lorenz Böhler, Vienna, Unfallkrankenhaus, XX, Webergasse 2. Professor Böhler will also accept announcements of lectures.

ITALY

THE NATIONAL CONGRESS OF THE ITALIAN SOCIETY OF ORTHOPAEDICS AND TRAUMATOLOGY

The thirty-fifth Congress of the society was held in Turin on October 21 to 23, 1950. At the opening session Professor Ugo Camera was presented with a volume compiled in honour of his methods and techniques, his contributions to the literature of surgery, and his twenty-five years of teaching. Foreign speakers emphasized particularly Camera's plea (so long ago as 1915) for early excision of war wounds, his indication in 1916 of the importance of muscular damage in the development of gas gangrene, and his work on reconstructive surgery in post-poliomyelitic paralysis.

At later sessions, devoted to diseases of the hip, *Dr C. Pais* (Bologna) and *Dr C. Marino-Zuco* (Rome) read papers supporting the technique of arthroplasty and the use of inert materials. It seemed that a body of Italian opinion still favoured the interposition of human tissue, however. Three French surgeons—*Drs Marcel Fèvre, Merle d'Aubigné* and *Robert Judet* (all of Paris)—spoke separately on aspects of and indications for the use of acrylic heads. *Dr R. Charry* (Toulouse) described his own technique of arthroplasty. *Professor J. Trueta* (Oxford) advocated Girdlestone's method for patients in whom either a cup arthroplasty or an acrylic head were contra-indicated. Other communications included papers by *Fèvre* on recurrent dislocation of the patella; *J. C. Scott*

(Oxford) on the use of the Robert Jones double adduction frame for congenital dislocation of the hip; Erlocher (Vienna) on the radiography of the nucleus pulposus; *Lorenz Böhler* (Vienna) on rehabilitation in fracture cases; and *Trueta* on osteomyelitis.

SOUTH AMERICA

LATIN-AMERICAN SOCIETY OF ORTHOPAEDICS

The first Latin-American Congress of Orthopaedics and Traumatology met in Montevideo and Buenos Aires on December 8 to 17, 1950, under two presidents—one, Dr Juan Farrill, nominated by the Latin-American Society, and the other, Dr Alberto Inclán, elected by Congress. The principle topics were osteoarthritis of the hip and injury of the elbow. Symposia were also arranged on lumbo-sciatic pain, congenital club-foot, giant-cell tumours, the results of surgical treatment for tuberculosis of the hip, fractures of the neck of the femur, and the bone bank.

CORRESPONDENCE

PERILUNAR DISLOCATION OF THE CARPUS

From Dr Michael Burman, M.D., New York

To the Editor,

Journal of Bone and Joint Surgery.

Dear Sir,

The term perilunar dislocation as discussed by H. Walden Fitzgerald (Journal, volume 32-B, August 1950, p. 386) presupposes carpal dislocation about a fixed semilunar bone. This is only one of a series of possible events consequent on the proximal transmission of force along the radial side of the upper extremity after a fall on the outstretched palm or equivalent injury. The major component of force is proximally directed, the orthogonally lesser, dorsally.

These are the probable sequential injuries. The advancing os magnum breaks through its neck and the caput may rotate. Or the caput of the os magnum is dislocated dorsally (in absolute dislocation) from the cotyloid joint of the scaphoid and semilunar bones to give the true perilunar dislocation. The caput of the os magnum strikes the scaphoid and breaks it; or it strikes the semilunar bone to rotate it and perhaps to dislocate it. Intruding itself between the scaphoid and semilunar bones, it separates them in gear manner. In the more usual form of this gear movement, the proximal part of the broken scaphoid and the semilunar bone turn ulnarly and the distal part of the scaphoid turns radially. To this is added volar rotation and sometimes translation of each component gear (Burman, M. S., Sindberg, S. E., Gersh, W., and Schmier, A. A.: American Journal of Roentgenology and Radium Therapy **1944, 51,** 4). This is the mid-carpal dislocation so well described by Stimson in his book.

The " give " of the many-jointed carpus allows the more proximal transmission of the force which usually dissipates itself in the Colles' fracture. If it travels still more proximally, the head of the radius, and sometimes the capitellum, breaks. The force is finally spent in the shoulder.

The clearly reproduced roentgenograms of Fitzgerald's case show gear rotation of the scaphoid and semilunar bones and not a perilunar dislocation. Each semilunar bone has been rotated ulnarly and volarly and therefore the caput of os magnum is in relative dorsal dislocation. The impact of the rotated scaphoid against the radial styloid process broke the process on the left side.

Very truly yours,

October 24, 1950. MICHAEL BURMAN.

Book Reviews

ORTHOPAEDIC SURGERY. By Walter MERCER, M.B., Ch.B., F.R.C.S. (Ed.), F.R.S. (Ed.), Professor of Orthopaedic Surgery, University of Edinburgh; Director of Orthopaedic Services to the South-Eastern Regional Hospital Board, Scotland. With a foreword by Sir John FRASER, Bart., K.C.V.O., M.C., F.R.S. (Ed.), F.R.C.S. (Ed.), M.D., Ch.M., F.R.A.C.S., F.A.C.S. Fourth edition. 9×6 in. Pp. x+1016, with 427 figures. Index. 1950. London: Edward Arnold & Co. Price 50s.

In its eighteen years of growth this book has increased in girth from 659 to 1016 pages, and one hastens to say that its additional flesh is not superfluous. It remains what it always has been—an indispensable book for candidates for any of the Fellowship examinations.

Although it is probably more scientific to arrange a text-book of orthopaedics on a pathological basis, an anatomical basis is much more useful. When confronted with a patient whose symptoms and signs point to the hip, the young graduate feels the need of a book of reference wherein all the common lesions of the hip are gathered together. This book fails in this respect; pseudocoxalgia, tuberculosis of the hip and slipped epiphysis are separated widely from one another. Classifications are odious, and are warranted only if they help in arriving at a diagnosis or in deciding on a treatment. Is anything to be gained by dividing coxa vara into capital, epiphysial, cervical and trochanteric? To an orthopaedic surgeon pseudocoxalgia in a late stage does not present itself as an example of coxa vara. Again, when the patient's history suggests a loose body in the knee joint, it never crosses the mind of a practical surgeon that he may be dealing with a sequestrum caused by tuberculosis, although Mercer includes this in a theoretical list of possible loose bodies (page 788). Dead operations should be decently interred; or, if an author is uncertain whether some surgeons still cling to an operation that he has himself discarded, he should indicate its probable early demise (pages 526 and 880). But, all in all, there is little dead wood in this book, and it is a worthy advertisement of the Edinburgh School of Orthopaedics.

If there was an 18 per cent mortality in 9 cases (page 338), how many patients died?—George PERKINS.

CHIRURGIE RÉPARATRICE. By Professeur R. MERLE D'AUBIGNÉ. 8×5 in. Pp. 343, with 51 figures. 1949. Paris: L'Expansion scientifique française. Price 21s. Paper cover.

This is an interesting book on reconstructive surgery by Professor D'Aubigné and his colleagues; and as one would expect from a team led by Professor D'Aubigné the result is stimulating and enterprising.

In a volume of rather moderate dimensions compared with most modern excursions into the same subject, a selection of contents has necessarily been made. The parts dealing with the spine, long bones, joints, nerves and vessels will be of most interest to the orthopaedic surgeon, and the chapter on skin will attract the attention of both plastic and orthopaedic surgeons. A selection of subjects is also made in each part. In the chapter on the spine, for example, attention is confined to the lumbo-sacral region, which is admittedly by far the most important region of the spine for both orthopaedic surgeon and patient.

The treatment of non-union of long bones by various forms of graft is discussed in detail; there is an interesting section on the use of the Küntscher nail in the treatment of ununited and malunited fractures together with a more ordinary section on the treatment of chronic traumatic osteomyelitis. Joint conditions are discussed under four headings. Under one are described eight cases of epiphysial destruction treated by bone grafting with very good functional results; under another, plastic operations on the extensor muscles and tendons of the knee are described for stiffness caused by traumatic adhesions; whilst a third gives a refreshingly confident account of results of the Smith-Petersen method of fusing the wrist. Peripheral nerve injuries are discussed and treated on accepted up-to-date lines, and there is an account of ganglion sympathectomy in which the authors have had more success in the treatment of post-traumatic causalgia in the upper than in the lower limb. Vessels which are the site of traumatic arterial and anterio-venous aneurysms receive due attention, and the authors stress the value of arteriography as an aid to diagnosis and treatment. The treatment of extensive traumatic skin loss is always an interesting

and often a difficult problem, and the subject is here dealt with in a full and satisfactory manner; the results described are very good.

Some of the later chapters are on the subjects of anaesthesia and shock—subjects which affect all orthopaedic work but are not always included even in books purporting to survey the whole field of orthopaedic surgery. They are thoughtfully written, and are a reminder that with the advent of more and more, and bigger and bigger, orthopaedic surgical undertakings, sight must not be lost of the effect on the condition of the patient as a whole. There are also chapters on restoration of function and rehabilitation.

The book is produced as a handy paper-backed volume that can be slipped easily into the pocket. The line drawings are admirable, the radiographic reproductions suffer their usual fate, whilst the picture illustrations clearly convey what is intended. The book should be read by all seriously interested in the surgical problems of orthopaedic surgery.—R. BROOMHEAD.

JOHN HUNTER. By S. Roodhouse GLOYNE, M.D. (Leeds), Consulting Pathologist, London Chest Hospital and King Edward VII Sanatorium, Midhurst. 9×6½ in. Pp. x+104, with 16 figures and colour frontispiece. Index. 1950. Edinburgh: E. & S. Livingstone Ltd. Price 15s.

Of all the men in our island who have taken a part in the extension of our knowledge of Medicine and of Biology, there is none with a life history which equals John Hunter's in interest, in unexpectedness, in bewilderment and in originality. His story has been told by several authors but by none better than Dr S. R. Gloyne in the fifty thousand words of this book. He has had no new source of information at his disposal but he has used the material accumulated by former biographers so as to tell a more continuous story than has been told before. His portrait gives us the conventional John Hunter—a man of defective education struggling to express ideas beyond the reach of his vocabulary. Of Hunter's "Treatise on the Blood, Inflammation and Gun-shot Wounds," the author passes this judgment: "On the whole it is not one of Hunter's best efforts and suffers from his dislike of definitions." He regards "the new operation which Hunter devised for the cure of popliteal aneurysm" as his "greatest contribution to surgery."

I devoted a good few years to the accumulation of materials for a life of Hunter. A few of my chapters have appeared in print. What was to be the opening chapter—"The Cradle of the Hunterian School"—appeared in a work commemorating Sir William Osler's seventieth birthday (1919); the materials to be employed in two other chapters on Hunter as an orthopaedic surgeon—his observations on the action of muscles and on the behaviour of living bone—were incorporated in "Menders of the Maimed" (1919). There were to be chapters on Hunter as a physiologist, as a botanist, as a zoologist, as a psychologist, as a pathologist, etc. Why did I abandon the project? My chief reason was that I failed to enlist the interest of the rising generation; they did not want to know what was being discovered in the eighteenth century but what was on foot in the medical world of the twentieth century and for this I did not blame them. But there was another reason—the materials at my disposal were those which were available to those that came after me. The four volumes of "The Works of John Hunter," edited by James F. Palmer (1837), is the quarry from which every biographer must draw his material and that quarry remains available to every generation. The other great quarry which I had always regarded as a permanency, the Hunterian collections, preserved in the Museum of the Royal College of Surgeons, was mangled by a German bomb; but, thanks to the devotion of Professor F. Wood Jones, many of the best Hunterian records are again on the shelves of the Museum. No one has possessed the perfect technique with which Hunter filled his shelves with specimens; he would have the best whatever the cost might be in labour or in money. Even when it came to choosing a wife he selected one of the most accomplished and most beautiful women of his time.—Arthur KEITH.

LES MALFORMATIONS DU NOUVEAU-NÉ CAUSÉES PAR LES VIROSES DE LA GROSSESSE ET PLUS PARTICULIÈREMENT PAR LA RUBÉOLE (Embryopathie Rubéoleuse). By Jean B. BOURQUIN. Preface by Professeur A. FRANCESCHETTI. 9½×6 in. Pp. iv+146, with 52 figures and 8 tables. 1948. Paris: Librairie E. Le François. Price not quoted.

This is a monograph on the abnormalities found in children whose mothers had contracted German measles at significant times before the births of the babies. The author has had a varied personal experience of this problem, and he reviews the literature apparently thoroughly.

There is little here to interest the orthopaedic surgeon as such. Most of the defects discovered

are to be found in the eye. There is an incidence of flat feet, club feet, fragilitas ossium and congenital dislocation of the hip which would not appear to be any greater than that in the general population. Though the significance of this work is enormous, its practical application to the deformities of the limbs and of the spine is not yet apparent.—D. Ll. GRIFFITHS.

FUSS UND BEIN: IHRE ERKRANKUNGEN UND DEREN BEHANDLUNG. By Georg HOHMANN, Direktor der Orthopädischen Universitätsklinik München. Fourth edition. 10×7 in. Pp. vii+504, with 451 figures. Index. 1948. München: J. F. Bergmann. Price 39 D.M.

HAND UND ARM: IHRE ERKRANKUNGEN UND DEREN BEHANDLUNG. By Georg HOHMANN, Direktor der Orthopädischen Universitätspoliklinik und Orthopädischen Klinik München. 10×7 in. Pp. viii+271, with 199 figures. Index. 1949. München: J. F. Bergmann. Price 24 D.M.

Fuss und Bein is the fourth edition of a work of which much of the original material was destroyed during the war. For this reason and perhaps for other circumstances of the post-war era, there is little discussion of recent developments in orthopaedic practice. Indeed, inspection of the ample bibliography reveals almost no reference to work of the past ten years. Conspicuously deficient is reference to British and American work. We are, therefore, provided with a valuable review of German orthopaedic practice in the leg and foot. Dr Hohmann's style is rather discursive but he has produced a useful teaching manual for the post-graduate student. Particularly good is his discussion of anatomical and physiological backgrounds, of investigative methods and operative indications. Yet it is strange that in his 500 pages, although there is room to touch upon a very few of the problems of the hip region, there is practically no mention of such lesions below the knee as osteomyelitis, tuberculosis, neoplasms, fractures, congenital pseudarthrosis of the tibia, nor of amputations. There is, however, a valuable account of von Bayer's " Synhapsis " theory of muscular action which leads Hohmann to stress the complexities of the subject " which should always be kept in mind before carrying out muscle transplantations if you do not wish them to be wrecked." One would have expected a critical review of tarsal arthrodesis for paralytic lesions instead of the three and a half pages, half of which comprise pictures. Upon hallux valgus there are thirty-six pages in which the virtues and abuses of metatarsal osteotomy are stressed. Keller's operation, referred to here as Brandes's, is discounted because it does not deal with the fundamental deformity; nevertheless " in spite of this it is a very serviceable method." In the section upon club foot, there is no mention of the work of Denis Browne. In spite of such criticisms the work represents sound German conservatism and should be in every well equipped orthopaedic library.

Hand und Arm is an entirely new work by Dr Hohmann and though much of the criticism of his *Fuss und Bein* may equally apply to this, there is a little more attempt to encompass modern work. For instance, Bunnell's work is discussed (as also that of the other " Amerikaner," Smillie of Dundee!). There is however little recognition of British and American work upon peripheral nerve injuries—nor is there much discussion of splintage for the hand or of after-treatment and rehabilitation. Tumours of the hand find no discussion except for enchondroma and glomus tumours. There is very little upon tuberculosis, and septic infections are practically excluded as belonging to the field of general surgery.

These two works give valuable insight into present-day German orthopaedics, but it is extraordinary that, with the paper available, each should not give a complete review of the subject matter implied in its title.—Norman CAPENER.

THÉORIE ET PRATIQUE DE L'OSTÉOSYNTHÈSE. By Robert DANIS. Professeur à la Faculté de Médecine de Bruxelles. 9½×6½ in. Pp. 298, with 274 figures, 1949. Paris: Masson et Cie. Price not quoted.

This is an important book. The beliefs and methods of Professor Danis have received wide acceptance in Continental clinics and the fact that they have attracted so little attention in this country is another example of the unfortunate segregation of western surgical thought into Anglo-American and Continental European compartments.

Danis believes in open reduction and in accurate internal fixation. His ideal is union of the

fracture " per primam," which to him means the complete absence of any visible callus. He claims to obtain this by compressing the fractured surfaces against each other, and all his special instruments have this idea of compression as the basis of their design. When possible, the compression is obtained by simple devices, such as very tight encircling wires in some spiral fractures, or in the equally tight wire suturing of comminuted fragments. More usually, however, he uses transfixing screws in such cases.

Whenever screws are used, with or without plates, the drilling of the holes has to be accurate. A special telescopic guide centres the drill. The screws are designed so that the space between the threads leaves six times as much tissue to withstand the pressure of the screw thread as that disturbed by the thread. Technique is simplified by having all screws, bolts and drills of 3 millimetre diameter, and all screw threads ·75 millimetre in depth.

In shaft fractures, compression is obtained by using the Danis *coapteur*. This is a sturdy plate with a single oval hole at one end, and three, five or seven circular holes according to its length. A screw-bolt projects into the terminal oval hole in the long axis of the plate. This bolt, screwed home against the end screw in the plate—the first screw to be inserted into that fragment—produces the impacting effect which is held to give the degree of compression which is essential for union per primam. The *coapteur* is Danis's best known appliance. Its use is very well established in Belgium.

The sections of the book dealing with special fractures contain an interesting reclassification of calcaneal injuries, a description of an osteotomy to rectify malunion in the tibial plateau and yet another device for Smith-Petersen nailing, but this book is much more than a description of appliances and of methods. It is a complete practice of osteosynthesis by a recognised master. It should, therefore, be widely studied in this country.—D. Ll. Griffiths.

B.R.A. REVIEW. Quarterly Journal of the British Rheumatic Association. Honorary Editor: A. Garland, M.D., M.R.C.P., D.P.H. Volume 1, No. 1, August 1950. Pp. 32, with some illustrations. The membership subscription is 10s. a year, due on enrolment.

This new journal, which is planned to interest the layman, is concerned primarily with the social welfare of the sufferer from " rheumatism " and with placing before the public the need for improvements in the facilities for treatment and rehabilitation of such patients. It is perhaps confusing that there should also be an Empire Rheumatism Council—an older body in which the dominant interest is in scientific research and education, particularly of the medical profession, but also greatly interested in the social problems of rheumatism on a more official plane. The two societies are obviously complementary and it seems a pity that there should be such duplication of organisation. The Review is edited by Dr A. Garland, and the Association's chairman is Colonel M. Stoddart Scott, O.B.E., M.D., M.P.

The education medically of the layman is a heavy responsibility for a doctor. The first article of this sort in the new Review is by Dr Francis Bach upon " Home Treatment of Rheumatism." He begins with a definition of physical medicine as the " art of science which associates itself with the management of disease by means of physical agents." Its scope includes the employment of a large number of physical methods with " manipulation, exercises and mechanical devices . . . in the diagnosis and treatment of disease." Clearly there is no means of distinguishing a specialist in physical medicine from any other specialist. Concerning domiciliary physiotherapy under the National Health Service Dr Bach would have " the physical medicine specialist responsible for the clinical diagnosis." To us the name of this specialist implies a person predominantly concerned with therapy, and therefore we would stress, what is so obvious to all except physical medicine specialists, that diagnosis must be the responsibility of the specialist in clinical medicine and surgery whatever his department, and that for rheumatism the prime responsibility is that of the general physician. It is of some significance that Dr Bach makes no mention of the importance of the general practitioner in the home treatment of rheumatism. If the association wishes to achieve success in its aims, it must support the work of the general practitioner on every possible occasion.

There are other useful articles dealing with spondylitis, rehabilitation, social services, advice upon invalid chairs, parliamentary notes and other news, and a description of Bath as a spa centre and how to get treatment there.—Norman Capener.

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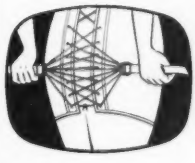

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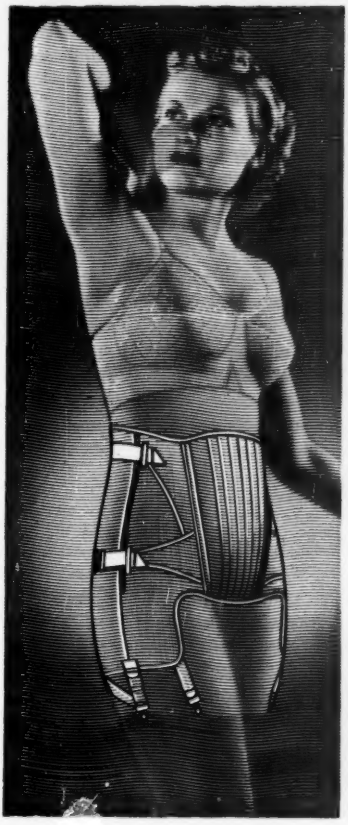

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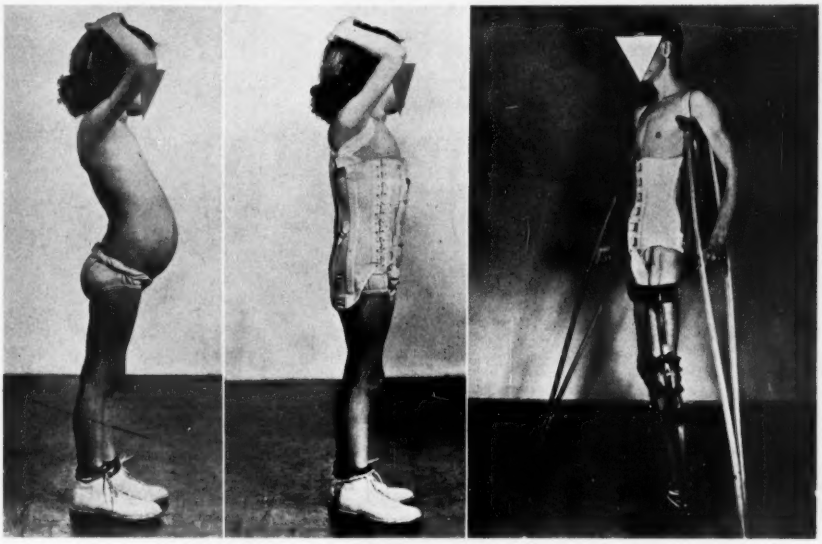

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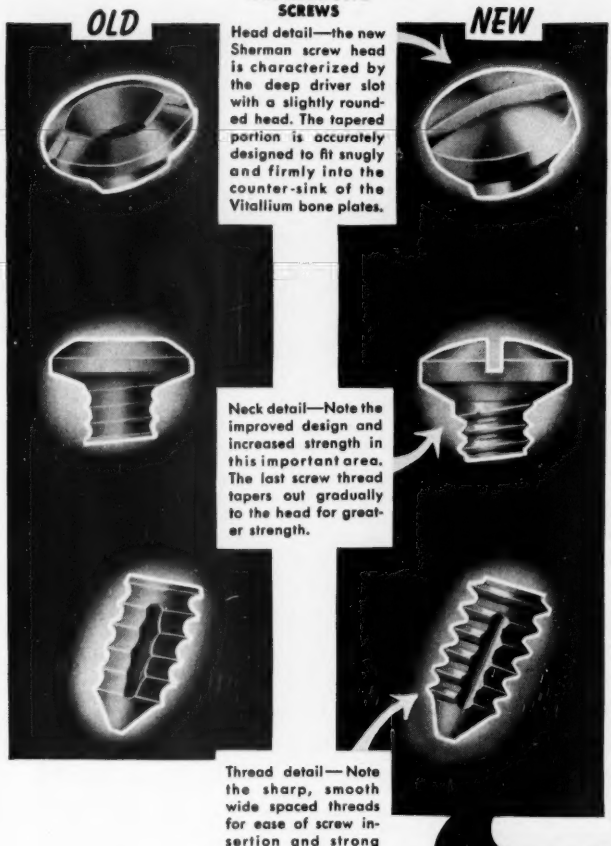

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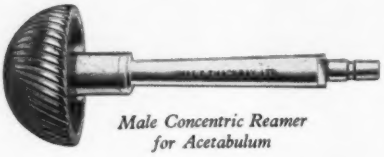

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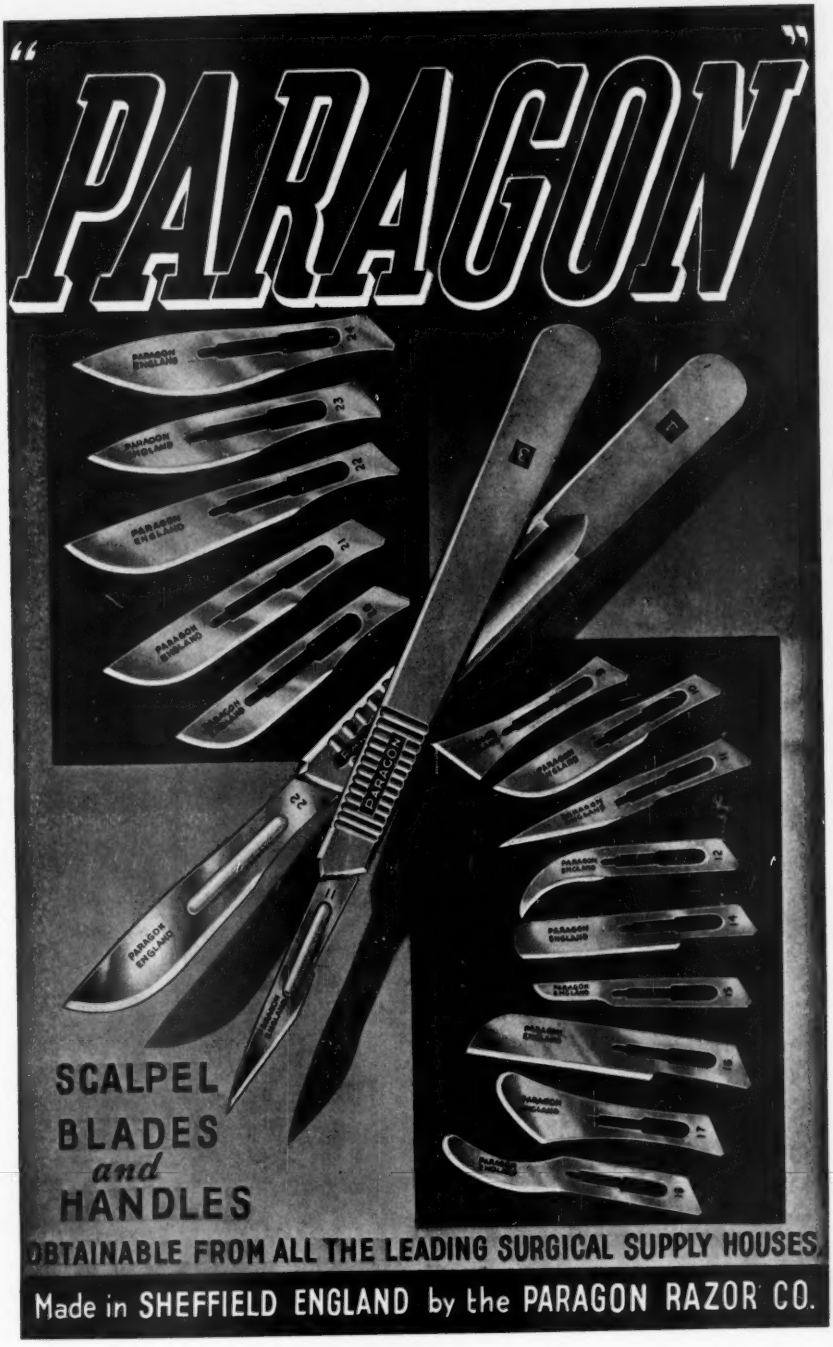
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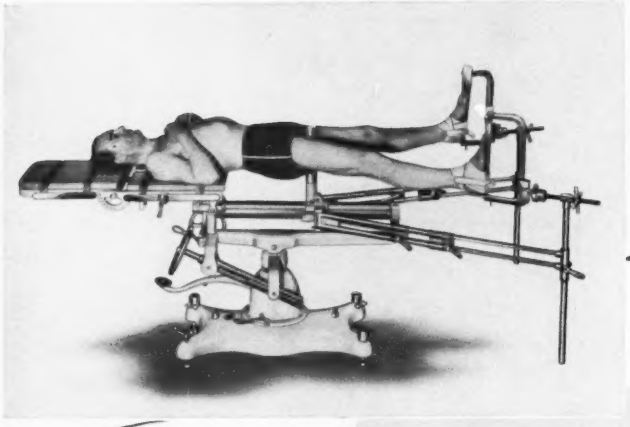

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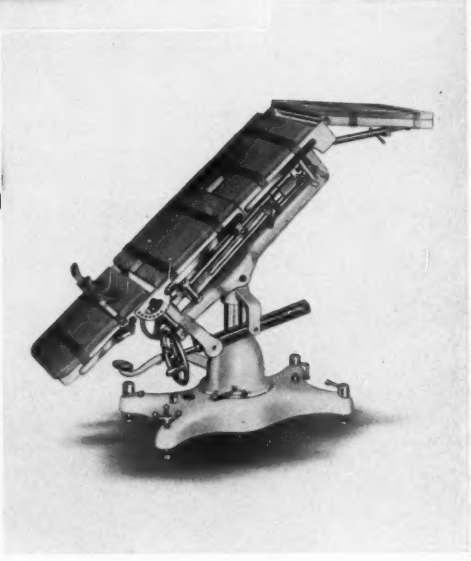

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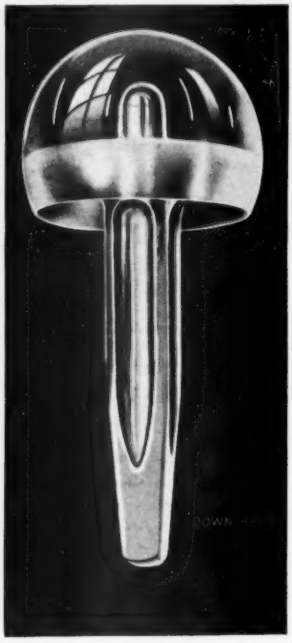

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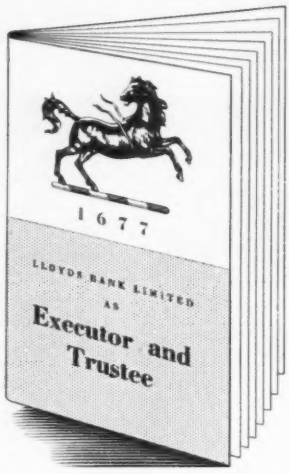

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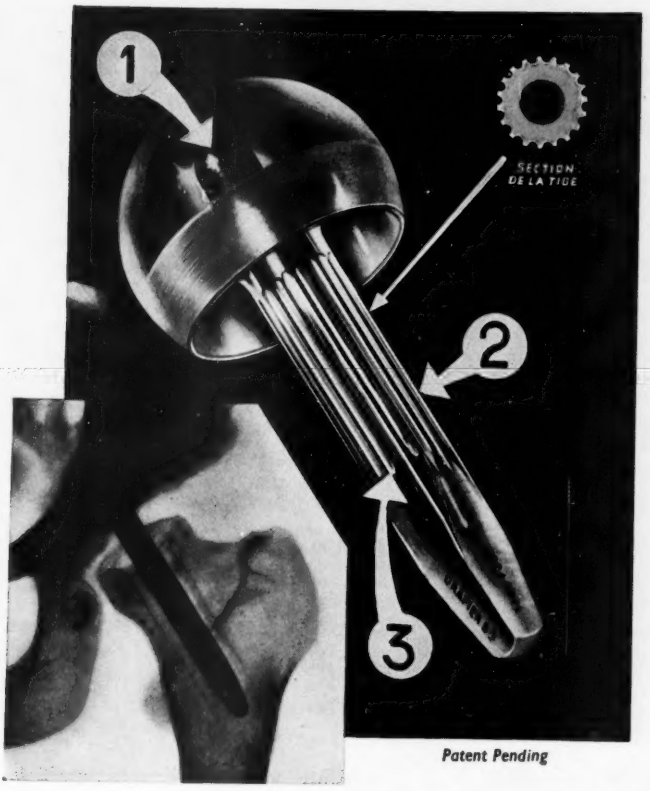

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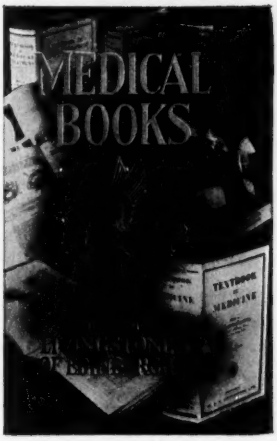

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